U.PORTO

DOUTORAMENTO

INVESTIGAÇÃO CLÍNICA E EM SERVIÇOS DE SAÚDE

Prevalência de marcadores da Hepatite B, Hepatite C, VIH e Sífilis em doadores de sangue em Angola, atendidos na Clínica Girassol durante o período de 2011 a 2016

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D

2025

Não basta ter começado; é preciso continuar. 1 Reis 19

A todas as pessoas que adquiriram

Infeção de Transmissão Transfusional

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Dissertação de Candidatura ao grau de Doutor em Investigação Clínica em Serviços de Saúde, submetida à Faculdade de Medicina da Universidade do Porto, Portugal.

DEDICATÓRIA

Em primeiro lugar, a Deus, autor da minha vida e protetor, o meu muito obrigado.

Ao meu Avó Eugénio Salessu que sempre me deu força, incentivo para formação, persistência e coragem para ultrapassar os obstáculos da vida, o meu muito obrigado pelas palavras sábias. Aos meus pais, com carinho especial à minha mãe Bia, pela coragem e orações, ao meu companheiro, às minhas filhas pela força que me transmitem, bem como aos meus irmãos, família que mesmo distante, sempre estiveram presentes e me estimularam a não desistir, se prontificaram nos momentos mais difíceis da minha vida que com generosidade e amor me têm ajudado e suportado, o meu muito obrigado, não tendo palavras para o descrever.

A todos os que se dedicam a pesquisar meios de controlar as infeções, nomeadamente, Hepatite B, Hepatite C, Vírus de Imunodeficiência Humana e Sífilis, esta catástrofe que assola a humanidade.

AGRADECIMENTOS

Com muita sinceridade e do fundo do coração, estendo o meu mais profundo apreço ao meu estimado orientador Professor Doutor António Carlos Megre Eugénio Sarmento, a minha eterna gratidão, pelo apoio constante, que com a sua sabedoria ao longo destes anos me orientou, por tudo que me ensinou nos mais diversos aspetos da minha vida e pela prontidão sempre que necessário. Estou genuinamente grata pela sua orientação e apoio inestimáveis.

Ao Professor Doutor Altamiro Manuel Rodrigues Costa Pereira que sempre foi amável, insistindo e persistindo para que fosse possível terminar esta jornada, agradeço as sugestões, incentivos e colaboração que proporcionou, pois, foi uma força motriz para concretização deste trabalho.

Ao Professor Doutor Luís Filipe Ribeiro de Azevedo, Diretor do Programa de Doutoramento em Investigação Clínica e em Serviços de Saúde (PDICSS) da Faculdade de Medicina da Universidade do Porto (FMUP), o meu muito obrigada pelo seu compromisso de excelência para comigo, orientação, revisões, experiência e conhecimento que me ajudou e inspirou muito a ultrapassar os limites da minha capacidade e habilidade que foram fundamentais para os resultados desta minha jornada académica. A minha eterna gratidão.

Ao Professor Doutor Lemuel Bornelli Cordeiro, que com sua sabedoria me orientou ajudou na organização e revisão desta tese, não tenho adjetivos, as minhas palavras são indescritíveis não alcançam, nem correspondem aquilo que realmente eu quero dizer e sinto, nomeadamente a amizade, o apoio constante que recebi, o meu muito obrigado.

Durante a minha jornada tive a oportunidade de conhecer o Professor Doutor Nelson Cuboia Fernando Cuboia, e agradeço pelos seus *"insights"* valiosos, encorajamento e *"feedback"* construtivo ao longo da minha formação de doutoramento e por ter sido o meu porto seguro; o meu ajudante na escrita das revisões sistemáticas e metanálise, assim como revisor dos manuscritos antes de serem submetidos para avaliação e validação do Senhor Professor Doutor Luís Filipe Ribeiro de Azevedo.

À Professora Doutora Milaydis Sosa Napolskij, que reviu os textos dos manuscritos em inglês da revisão sistemática os meus sinceros agradecimentos.

À Professora Doutora Cláudia Camila Dias, a quem estou profundamente grata, tendo estado sempre presente desde o início desta caminhada e que muito contribuiu para rever com toda a paciência, persistentemente os dados estatísticos, aconselhando-me a não desistir nesta longa jornada, os meus sinceros agradecimentos.

À Comissão Executiva, na pessoa do Vogal para o Ensino e Pesquisa Dr. Vasco Júnior Sabino da Silva e do Gabinete do Ensino Pós-Graduação e Pesquisa (GEPP) da Clínica Girassol, por me terem autorizado, concedido tempo para que continuasse a jornada, o que me permitiu dedicar plenamente aos meus esforços de investigação para prosseguir os meus estudos de doutoramento. Dirijo os meus votos sinceros de agradecimento.

Ao Serviço de Imunohemoterapia e ao Banco de Sangue da Instituição, especialmente à Dra. Adis del Carmen Cogle, que esteve sempre pronta e disponível para ajudar, agradeço o apoio e acolhimento.

À minha família, meus pais, irmãos, companheiro e filhas, pelo amor, carinho, respeito, apreço que tenho por vocês, especialmente pela minha mãe, muito obrigada pelas orações.

A todos os meus colaboradores de maneira indireta ou direta, que muito me incentivaram a realizar este trabalho, fruto de pesquisa clínica e revisão sistemática com metanálise que ao longo do tempo me proporcionou crescimento não só intelectual, mas pessoal e me ensinou que o conhecimento é uma fonte inesgotável.

Agradeço ao Departamento de Medicina da Comunidade, Informação e Ciências de Decisão em Saúde (MEDCIDS), da Faculdade de Medicina da Universidade do Porto e ao Centro de Investigação em Tecnologias e Serviços de Saúde (CINTESIS) por me proporcionar um ambiente académico propício.

De acordo com o n.º 2 do artigo 8º do Decreto-Lei n.º 388/70, fazem parte desta dissertação as seguintes publicações e os artigos submetidos a publicação:

Revisão sistemática e meta-análise:

- *Seroprevalence of Hepatitis B virus surface antigen among African blood Donors: a systematic review and meta-analysis.* Publicado na revista *Frontiers in Public Health* em 21 de outubro de 2024.
- *Seroprevalence of human immunodeficiency virus in African blood donors: a systematic review and meta-analysis.* Publicado na revista *eBioMedicine part of The Lancet Discovery Science* em julho de 2024. (www.thelancet.com Vol 105 July, 2024).
- *Seroprevalence and Temporal Trends of Hepatitis C Virus in African Blood Donors: A Systematic Review and Meta-analysis.* Submetido à revista ***Scientific Reports***, em maio de 2025, submetido ao processo de revisão pelos pares e aguarda decisão final dos editores.
- *Seroprevalence of Syphilis in Blood Donors in African Countries: A Systematic Review and Meta-analysis.* Submetido à revista *BMC Public Health* em 25/04/2025, submetido ao processo de revisão pelos pares e aguarda decisão final dos editores.

Estudo observacional

- *Seroprevalence of viral transfusion transmissible infections (HBsAg, anti-HCV, anti-HIV, Syphilis) and Coinfection among healthy volunteer blood donors during 5 years in Luanda, Angola*. Publicado na revista *The Brazilian Journal of Infectious Diseases* em 27-11-2023. BRAZ J INFECT DIS. 2023;27(6):103704. (www.elsevier.com/locate/bjid).
- *Incidence of hepatitis B and C in voluntary blood donors in a private clinic in Angola from 2011 to 2016*. Angelina Edna Quintas, Adis Del Carmen Cogle, Cláudia Camila Dias, Altamiro Costa-Pereira, António Carlos Sarmento, Lemuel Bornelli Cordeiro. *Advance Research Journal of Multidisciplinary Discoveries*, I Vol.48 I Issue-1, Chapter-1, E-ISSN: 2456-1045. (April-2020 EDITION).
- *Trends in Human Immunodeficiency Human Virus Type 1/2 among Young Adult Blood Donors, from 2011 to 2016, Attending a Private Clinic in Angola. Retrospective Study of Prevalence.* Quintas E, Cogle ADC, Caetano F, Dias CC, Sebastião A, Van-Dúnem J, Pereira AC, Sarmento A, Cordeiro L. *Journal of Infectious Diseases and Pathogenesis*. 2018, Volume I, Issue-2:206, ISSN:255-7939

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Apresentado no Simpósio Internacional em Doenças Infeciosas e Vacinas, em Novembro 25-26, 2024, Porto-Portugal. 2513-5283.

LISTA DE ABREVIATURAS

AcHBc	Anticorpo do core do vírus da hepatite B
AgHBe	Antigénio "e" do vírus da hepatite B
AgHBs	Antigénio de superfície do vírus da hepatite B
Anti-HBe	Anticorpo "e" do vírus da hepatite B
AcHBs	Anticorpo de superfície do vírus da hepatite B
ADN	Ácido dexosirribonucléico
anti-VHC	Anticorpo para o vírus da hepatite C
anti-VIH	Anticorpo para o vírus de imunodeficiência humana
ARN	Ácido ribonucléico
AgHBs	Antigénio de superfície do vírus da hepatite B
AgHBe	Antigénio "e" do vírus da hepatite B "e": envelope
Anti-HCV	Anticorpo do vírus da hepatite C
CDC	*"Centers for Disease Control and Prevention"*
CINTESIS	Centro de Investigação em Tecnologias e Serviços de Saúde
CHC	Carcinoma hepatocelular
DeCS	Descritores em Ciências da Saúde
DST	Doenças sexualmente transmissíveis
DSVNR	Doadores de sangue voluntários não remunerados
EUA	Estados Unidos da América
FDS	Familiares de doadores de sangue
FRBD	Familiares de doadores de sangue não remunerados
FTA/ABS	Fluorescent Treponemal Antibody Absorption Test
GEPP	Gabinete do Ensino Pós-Graduação e Pesquisa da Clínica Girassol
HAART	Terapêutica antirretroviral de alta eficácia
HCC	Hepatocarcinoma

HB	Hepatite B
HC	Hepatite C
ITT	Infeções de transmissão transfusional
MEDCIDS	Departamento de Medicina da Comunidade, Informação e Ciências de Decisão em Saúde
LAV	Lymphadenopaty associated virus
OMS	Organização Mundial de Saúde
RPR	Rapid Plasma Reagin
SIDA	Síndrome de imunodeficiência adquirida
TPHA	*Treponema pallidum Hemagglutination Test*
TAN	Teste de amplificação de ácidos nucléicos
VHB	Vírus da hepatite B
VHC	Vírus da hepatite C
VIH	Vírus de imunodeficiência humana
VNRBD	Doadores de sangue voluntários não remunerados
VDRL	*Venereal Disease Research Laboratory*

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RESUMO

Infeção de transmissão transfusional (ITT) é toda a infeção que é adquirida através da transfusão de sangue. Em Angola, estudos sobre ITT e suas consequências são escassos. Por outro lado, apesar de existirem estudos de investigação realizados noutros países com resultados significativos acerca da relação entre as ITT e suas consequências, existe necessidade de uma melhor compreensão desta situação nos países em desenvolvimento, para uma melhor adaptação dos programas de prevenção e controlo das referidas infeções. O resultado de uma ITT pode ser crónico, muito debilitante e ter grande impacto social, familiar e conferindo vulnerabilidade a nível psicopatológico, que acarreta custos acrescidos com o tratamento. O Serviço de Imunohemoterapia e Banco de Sangue da Clínica Girassol realiza o rastreio destas infeções.

O objetivo da presente dissertação foi o de estudar primeiramente através de um estudo observacional, a prevalência das infeções de transmissão transfusional, nomeadamente marcadores da hepatite B, hepatite C, VIH e Sífilis, em Angola, em particular na Clínica Girassol, durante o período de 2011 a 2016. Posteriormente, realizaram-se revisões sistemáticas e meta-análise, para conhecer e caracterizar a prevalência destes marcadores serológicos em doadores de sangue nas 5 regiões de África, nomeadamente, Norte, Ocidente, Oriente, Centro e Sul. Surge então a necessidade de aprofundar a investigação utilizando o PRISMA-Statement Guideline updated in 2020 e o protocolo do estudo foi registado na PROSPERO com o número CRD42023395616.

Para a revisão sistemática e meta-análise foi utilizada uma estratégia de pesquisa e seleção criteriosa dos estudos primários, desde o início, isto é, entre 1990 e março de 2024, tendo sido excluídas séries de casos, comentários editoriais e estudos com dados duplicados. Nestes estudos ficou demonstrado que a seroprevalência de AgHBs entre doadores de sangue foi de 6,93% (95% CI: 5,95 a 7,97%); VHC de 2,46% (95% CI: 1,97 a 3,00%); VIH de 2,66% (95% CI: 2,17 a 3,20%) e sífilis foi de 2,47% (95% CI: 1,81 a 3,24%), em doadores de sangue nas 5 regiões de África. Na generalidade, estes resultados quando comparados com os outros continentes, demostrou uma seroprevalência alta.

Para o estudo observacional de prevalência, tentamos perceber os fatores que motivam a doação de sangue, no que concerne aos doadores voluntários não remunerados e seus familiares, estudar a prevalência de cada marcador serológico, o número total de doadores de sangue com resultados positivos. Neste sentido, participaram neste estudo Descritivo Observacional Retrospetivo de Prevalência, 3016 (2734 positivos e 282 negativos) doadores voluntários de sangue sujeitos de pesquisa, através da utilização de uma base de dados de marcadores com resultados positivos para a Hepatite B, C, VIH e Sífilis rastreados de 2011 a 2016. Foram registados os dados demográficos. A análise foi efetuada utilizando o programa de análise estatística de dados SPSS® v.24.0 (Statistical Package for the Social Sciences). Todos os doadores antes da doação de sangue

preencheram e assinaram o consentimento informado. No estudo, os doadores de sangue com resultados positivos perfizeram 2734. Apresentaram idades compreendidas entre 18 e 64 anos. A maioria eram homens com 2467 (90%) e 267 (10%) mulheres e a média encontrada das idades foi de 32±9 anos. Mil e trezentos e setenta e três doadores/2734 (50%) apresentaram o antigénio de superfície do vírus da Hepatite B (AgHBs) positivo; 731/2734 (27%) anticorpo do core do vírus da Hepatite B (AcHBc) positivo e 69/1373(5%) simultaneamente AgHBs e AcHBc. O anticorpo para o vírus da Hepatite C (anti-HCV) foi positivo em 140/2734 (5,1%) doadores e o anticorpo para o vírus de imunodeficiência humana em 191/2734(7%) doadores. Quanto à sífilis, 436/2184(20%) doadores apresentaram resultados de serologia positivos para o Treponema pallidum, sendo a maioria, doadores do sexo masculino com 384/2184 (17,5%) e 52/2184 (2,4%) do sexo feminino.

Concluindo, os resultados do estudo revelaram que os marcadores serológicos pesquisados em todas as amostras estudadas, mostraram uma prevalência elevada de contato com estas infeções nesta população, o que demonstrou a importância de rastrear os doadores para garantir a segurança da transfusão e assim evitar ITT, motivo pelo qual o rastreio deve ser intensificado.

SUMMARY

Transfusion transmission infection (TTI) is any infection that is acquired through blood transfusion. In Angola, studies on Transfusion Transmission Infections (TTI) and their consequences are scarce. On the other hand, although there are research studies carried out in other countries with significant results on the relationship between TTIs and their consequences, there is a need for a better understanding of this situation in developing countries, in order to better adapt the prevention and control programs of these infections.

The result of the consequences of a TTI can be chronic, very debilitating and has great social and family impact and confers vulnerability at the psychopathological level, which entails increased costs with treatment. The Immunohemotherapy Service and Blood Bank of Clínica Girassol, performs the screening of these infections.

The objective of this dissertation was to study/show, through an observational study, the prevalence of transfusion transmission infections, namely markers of Hepatitis B, Hepatitis C, HIV and Syphilis, which nowadays occur in Angola, particularly at Clínica Girassol, during the period from 2011 to 2016. Subsequently, systematic reviews and meta-analysis were carried out to know and characterize the prevalence of these serological markers in blood donors in the 5 regions of Africa namely North, West, East, Central and Southern Africa. For the systematic review and meta-analysis, the PRISMA-Statement Guideline updated in 2020, was used and the study protocol was registered in PROSPERO with the number CRD42023395616. A research strategy and careful selection of studies was used from the beginning, between 1990 and March 2024, and case series, editorial comments and studies with duplicate data were excluded. These studies showed that the seroprevalence of AgHBs among blood donors was 6.93% (95% CI: 5.95 to 7.97%); HCV was 2.46% (95% CI: 1.97 to 3.00%); HIV was 2.66% (95% CI: 2.17 to 3.20%) and syphilis was 2.47% (95% CI: 1.81 to 3.24%), in blood donors across the 5 regions of Africa. In general, these results, when compared with other continents, demonstrated a high seroprevalence.

For observational study, we try to understand the factors that motivate blood donation, with regard to voluntary unpaid donors and family members of blood donors, then study the prevalence of each serological marker, the total number of blood donors with positive results. In this sense, 3016 [2734 positive and 282 negative] voluntary blood donors research subjects in this Descriptive/Observational Retrospective Prevalence study, using a database of markers with positive results for Hepatitis B, C, HIV and Syphilis in donors screened from 2011 to 2016. Demographic data were recorded.

The analysis was performed using the statistical data analysis program SPSS® v.24.0 (Statistical Package for the Social Sciences). All donors before blood donation completed and signed the informed consent.

In our study, blood donors with positive results totaled 2734. They were aged between 18 and 64 years. The majority were men with 2467 (90%) and 267 (10%) women and the mean age was 32±9. One thousand three hundred and seventy-three donors/2734 (50%) had positive hepatitis B virus surface antigen (HBsAg); 731/2734(27%) positive hepatitis B virus (HBcAc) core antibody and 69/1373(5%) simultaneously HBs and AcHBc. The antibody to the hepatitis C virus (anti-HCV) was positive in 140/2734 (5%) donors and the antibody to the human immunodeficiency virus in 191/2734 (7%) donors. Regarding syphilis, 436/2184 (20%) donors tested positive serology for Treponema pallidum, with the majority being male donors with 384/2184 (17.5%) and 52/2184 (2.4%) females.

In conclusion, the results of the study revealed that the serological markers researched in all the samples studied, showed a high prevalence of contact with these infections in this population, which demonstrated the importance of screening donors to ensure the safety of the transfusion and thus avoid ITT, which is why screening should be intensified.

INTRODUÇÃO

1. INTRODUÇÃO

1.1. Breve Introdução Geral

O presente trabalho resulta da impossibilidade da colheita de dados necessários para desenvolver o projeto inicialmente proposto para a dissertação. Surgiu então, este novo projeto, desenvolvido no Serviço de Imunohemoterapia e Banco de Sangue da Clínica Girassol.

O **capítulo 1** a Introdução inclui a estrutura da Tese. O Referencial Teórico procura pormenorizar a problemática das infeções de transmissão transfusional (ITT) nos Bancos de Sangue de Angola e do continente africano. No **capítulo 2**, descreve-se resumidamente a Epidemiologia dos quatro marcadores de ITT mais comuns, onde constam cinco artigos, um que faz referência ao estudo observacional descritivo de prevalência realizado em doadores de sangue na Clínica Girassol em Luanda-Angola e outros quatro artigos de revisão sistemática e meta-análise. Neste capítulo faz-se também referência da coinfeção destes marcadores.

O **capítulo 3** descreve os objetivos e os métodos. No **capítulo 4** faz-se referência aos resultados e discussão do estudo observacional em doadores de sangue da Clínica Girassol. Neste capítulo, são incluídos os três artigos publicados do nosso estudo observacional, isto é, os resultados da investigação. A conclusão dessa dissertação está no **capítulo 5**, onde são abordados alguns pontos a reter dos dados do Banco de Sangue da Clínica Girassol. O **capítulo 6** aborda as limitações e considerações finais deste trabalho. Importante mencionar que a autora optou por trazer oito trabalhos de sua autoria sendo seis artigos já publicados e dois manuscritos (um aceite para publicação e outro submetido ao processo de revisão pelos pares e, aguarda decisão final dos editores), que deram fundamentação para essa dissertação e serão mencionados ao longo da dissertação.

Objetivo geral:

- Identificar a seroprevalência dos marcadores da Hepatite B, Hepatite C, Vírus de Imunodeficiência Humana e Sífilis em Doadores de Sangue nas regiões de África, que se espelha nos quatro artigos de revisão sistemática e meta-análise.

Objetivos específicos:

- Identificar a seroprevalência de marcadores com resultados positivos para a Hepatite B, Hepatite C, VIH, Sífilis e Coinfeção em doadores de Sangue da Clínica Girassol-Angola;
- Demonstrar potenciais coinfeções em doadores de sangue da Clínica Girassol-Angola que se espelha nos quatro artigos do Estudo Observacional.

1.2. Apresentação

Esta tese aborda quatro das principais ITT e a coinfeção destes marcadores. A tese fundamentou-se numa minuciosa análise da literatura sobre o tema, através de revisões sistemáticas e meta-análise e ainda um estudo observacional descritivo de prevalência na Clínica Girassol em Luanda-Angola.

Este estudo foi delineado para conhecer e ter uma visão global da seroprevalência dos marcadores da hepatite B, hepatite C, vírus de imunodeficiência humana e sífilis dos 54 países do continente africano. Atendendo à extensão do trabalho, foi decidido separar a revisão sistemática e meta-análise em quatro (dois artigos e 2 manuscritos). A partir de um referencial teórico construído com aquilo que foram as melhores evidências disponíveis nos trabalhos consultados, propôs-se uma discussão. Esta reflexão aprofundada pretendeu reunir os aspetos do entendimento relativamente ao rastreio, bem como responder a questões de forma a saber de que maneira se encontra a situação atualmente no continente africano. Dever-se-á discutir, estratégias para melhorar a abordagem da educação para a saúde, bem como criar e determinar uma via fácil para cativar a população para a doação de sangue e assim podermos conhecer melhor a epidemiologia no nosso meio.

Os outros quatro artigos, que fazem parte do estudo observacional, são estudos descritivos retrospetivos de prevalência em que se utilizou a base de dados do Serviço de Imunohemoterapia e Banco de Sangue da Clínica Girassol de Luanda em Angola.

1.2.1. Definições das Infeções de Transmissão Transfusionais

a) Infeções de Transmissão Transfusionais (ITT)

São todas as infeções que são adquiridas através da transfusão de sangue. Este trabalho abordará apenas as infeções pelo vírus da hepatite B, hepatite C, vírus de imunodeficiência humana, sífilis e coinfetados.

b) Conceito de Marcadores Virais

Marcadores serológicos virais são marcadores de contato antigo ou recente com esses vírus. Vírus é o nome genérico que se dá aos agentes infeciosos obrigatórios das células, que possuem uma estrutura proteica bem definida, com ou sem invólucro de reduzidas dimensões, com simetria cúbica ou helicoidal. Replicam-se a partir do material genético representado na partícula infeciosa que é o virião, por um único tipo de ácido ribonucleico (vírus ARN, que é o caso da hepatite C) ou de ácido desoxirribonucleico (vírus de ADN, como é o caso da hepatite B)[5].

• Vírus da hepatite B

As hepatites virais são infeções sistémicas, causadas por vírus hepatotrópicos. Os tipos mais prevalentes são as hepatites A, B, C, D e E, sendo as hepatites B e C as responsáveis por 96% da mortalidade geral das hepatites[1],[2]. Esses agentes etiológicos são de distribuição universal e têm em comum o hepatotropismo cujo o reservatório natural é o homem. A transmissão é por via oral, sexual ou sanguínea com possibilidade de cronificação, exceto a hepatite A[3],[4].

O vírus da hepatite B (VHB) é o vírus da hepatite mais estudado e complexo, constituído por uma partícula infetante que consiste em um core viral (núcleo viral) com um invólucro proteico de superfície[1], [2 [5]. Do ponto de vista dos marcadores serológicos, o vírus da hepatite B pertencente à família Hepadnaviridae, que infecta apenas os seres humanos, é um vírus de ácido desoxirribonucleico (ADN). Estruturalmente, apresenta distintos antigénios (Ag), nomeadamente, o Ag de superfície (AgHBs); o Ag do core (AgHBc) e antigénios centrais (AgH-Be). Alguns anticorpos tais como, Anti-HBs; Anti-HBc (IgM e IgG) e Anti-HBe são fundamentais para o diagnóstico e acompanhamento da infeção pelo vírus da hepatite B, além de material genético constituído por ADN circular de hélice parcialmente dupla[5, 6]. O core contém ácido desoxirribonucleico ADN circular de dupla cadeia, ADN polimerase e replica-se no núcleo de hepatócitos infetados. O invólucro proteico adere ao citoplasma e, por motivos desconhecidos, é produzido em grande excesso.

O antigénio de superfície do vírus da hepatite B (AgHBs) e o anticorpo do *core* do vírus da hepatite B, são marcadores solicitados quando há suspeita de infeção pelo vírus da hepatite B, sendo considerados marcadores de rastreio da infeção. Após a exposição ao vírus, o primeiro marcador serológico a aparecer na infeção aguda, nas primeiras 4 semanas é o AgHBs, alcançando níveis indetetáveis nas 24 semanas[7].

O anticorpo de superfície do vírus da hepatite B (AcHBs) é o único anticorpo que confere imunidade contra o vírus da hepatite B, está presente nas primeiras 10 semanas após desaparecimento do antigénio de superfície. É o anticorpo contra o antigénio de superfície do vírus da hepatite B e, é o único que confere imunidade ativa. Geralmente, este marcador está presente entre a primeira e a décima semana após desaparecimento do AgHBs. O anticorpo do core do vírus da hepatite B (Anti-HBc) classe IgG e IgM significa, contato passado ou contato recente com o vírus da hepatite B respetivamente[6], [7].

O Anti-HBc IgM, marcador de infeção recente, é encontrado no soro 32 semanas após infeção, mas pode estar presente na fase crónica quando ocorre reinfeção ou agudização da infeção. O anti-HBc IgG é marcador de infeção passada, permanece para a vida toda nos indivíduos que tiveram infeção pelo vírus da hepatite B. Caracteriza o contato prévio com o vírus.

O antigénio "e" do vírus da hepatite B (AgHBe) indica alta infecciosidade e caracteriza a fase de replicação. O anticorpo "e" do vírus da hepatite B (Anti-HBe) indica fim da fase de replicação viral e surge após desaparecimento do AgHBe.

O VHB é mais frequentemente transmitido por via parenteral, por sangue contaminado ou hemoderivados contaminados, de agulhas compartilhadas por usuários de drogas injetáveis e ainda se mantém frequente principalmente no continente africano. No entanto, o risco de contaminação pelo VHB é maior em doentes dialisados, em doentes em unidades de oncologia, bem como profissionais da área de saúde em contato com sangue.

• Vírus da hepatite C

O vírus da hepatite C pertence à família Flaviviridae do género Hepacivirus e possui o seu material genético constituído por um RNA de cadeia única ou simples. O marcador serológico é o anti-VHC[7], e deve ser pedido na suspeita de infeção pelo vírus da hepatite C. O vírus da hepatite C (VHC) é um vírus de RNA-Flavivírus, que com alguma frequência é transmitido por via parentérica principalmente em consumidores ativos de drogas que compartilham agulhas e em tatuagens, aplicação de piercings com material não estéril. A transmissão pela transfusão sanguínea e hemoderivados também é possível. Quando no soro de indivíduos com suspeita de infeção pelo vírus da hepatite C é encontrado o anticorpo anti-VHC, não define se a infeção é aguda, crónica ou curada[7].

Foi introduzido o teste oral rápido do anticorpo de VHC (OraQuick® HCV Rapid Antibody Test) [8], que poderá mudar completamente a abordagem do diagnóstico de hepatite C facilitando a possibilidade de rastrear milhões de indivíduos no mundo inteiro, em particular nos países em vias de desenvolvimento[9].

Nota: Na hepatite B assim como hepatite C, recomenda-se a avaliação da carga viral, utilizando testes de biologia molecular[7]. Esse assunto não será tema desta discussão.

• Vírus de Imunodeficiência Humana (VIH)

O vírus de imunodeficiência humana é um vírus de RNA-Retroviridae, que está na origem da Síndrome de Imunodeficiência Adquirida (SIDA). A pesquisa dos anticorpos VIH-1 e VIH-2 é o exame que visa detetar a infeção em indivíduos com idade igual e superior há 2 anos. Caso haja confirmação serológica, isto é, resultado positivo, está preconizado a realização do teste Western Blot (WB). São várias as formas de transmissão, mas aqui faz-se referência à transfusão de sangue, apesar de existirem outras vias de transmissão.

A SIDA é a manifestação clínica avançada resultante de um quadro de imunodeficiência causada pelo vírus da imunodeficiência humana (VIH), que é transmitida por via parenteral, sexual ou vertical[10]. O vírus da imunodeficiência humana pertence à família Retroviridae, subfamília Lentiviridae[11], tendo um efeito citopático a curto prazo causando uma infeção crónica subsequente. O VIH infeta os macrófagos, as células dendríticas e os linfócitos T. As células com o marcador CD4+ são preferencialmente infetadas pelo vírus que expressam na sua superfície as partículas da proteína viral, reconhecidas pelos linfócitos T CD8+ e como consequência, ocorre a sua destruição[12,13].

• Sífilis

A Sífilis é uma doença infeciosa transmitida pela via sexual e vertical[14], causada pelo *Treponema pallidum*, do género Treponema, da família dos Treponematacea[15]. Os marcadores serológicos são os testes treponémicos tais como *Fluorescent Treponemal Antibody Absorption Test* (FTA/ABS) e *Treponema pallidum Hemagglutination Test* (TPHA). Os testes não treponémicos

são nomeadamente, *Venereal Disease Research Laboratory* (VDRL) e do *Rapid Plasma Reagin* (RPR). O teste VDRL, é o mais utilizado nos dias de hoje para avaliação da atividade da doença. O Teste Imunoenzimático - *Enzyme linked Immunosorbent Assay* (ELISA), são específicos e qualitativos nos quais empregam-se os antigénios do *T. pallidum*[16], [17], [18]. Foi desenvolvido uma análise com base em ureia (ELISA) teste-imunoenzimático, para deteção de anticorpos reagina no soro[19].

As infeções causadas por estes agentes, permanecem um problema importante e ameaçador à vida, muito comum principalmente em África. A incidência de mortalidade por esses agentes permanece alta. Novos esforços estão a ser feitos para a melhoria da sobrevida e qualidade de vida das pessoas portadoras destas infeções.
Determinantes laboratoriais são extremamente necessárias no rastreio do doador de sangue, para melhor manuseamento e assim evitar a transmissão de doenças através da doação de sangue. Os doentes raramente morrem da sua doença, mas sim das suas complicações. Ainda, não é possível impedir a morte por doenças tratáveis, embora nos dias de hoje conheçamos mais sobre as doenças, seu processo patológico, do que jamais sonharíamos. Talvez nada ilustre melhor essa questão que um breve resumo histórico sobre essas doenças, nomeadamente, hepatite B, hepatite C, vírus de imunodeficiência humana e sífilis, transmitidas por transfusão sanguínea, não esquecendo as outras vias de transmissão.

1.2.2. Referencial Teórico

O referencial teórico procura pormenorizar a problemática das ITT nos Bancos de Sangue de Angola e do continente africano.
Em África e não só, a segurança na transfusão sanguínea, está comprometida por múltiplos e diversos fatores, tornando elevada a prevalência de infeções por transfusão de sangue. Por isso, estratégias de diagnóstico são vitais. Os testes rápidos de diagnóstico foram amplamente adotados nos países em vias de desenvolvimento, mas, para a eficácia na segurança sanguínea, testes altamente sensíveis e a seleção estrita de doadores de sangue de baixo risco é indispensável. O período de janela pré-serológico permanece uma fonte de risco residual para transmissão de infeções durante a transfusão de sangue. O antígeno em combinação com testes de anticorpo rápido poderia contribuir significativamente para encurtar o período de janela imunológica.

Apesar das limitações, o teste rápido de diagnóstico, continua a contribuir significativamente para a segurança do sangue, como custo-efetivo para melhorar a triagem das ITT e reduzir a sua transmissão em ambientes rurais de recursos limitados[20].

O risco de transmissão de infeções por transfusão sanguínea tem sido estudado em pormenor nos países desenvolvidos, mas negligenciado em países subdesenvolvidos. Uma revisão sistemática realizada com dados da OMS, estima que o risco global mediano de se infetarem com VIH, VHB e VHC de uma transfusão de sangue em África, sobretudo na Subsaariana, foi de 1; 4,3 e 2,5 infeções por 1000 unidades, respetivamente[21], [22], [23].

Nas publicações citadas nesta tese, cada vez mais observamos um aumento dos marcadores positivos em doadores que pensavam que eram saudáveis. Daí a importância de rastrear e sensibilizar a população para o rastreio. Práticas de transfusão de sangue em todo o mundo enfatizam a segurança e a proteção da vida humana. Infeções como VHB, VHC, VIH são motivo de grande preocupação por causa da sua prolongada viremia e seu estado latente[24]. O crescimento da população pobre e sem recursos de cuidados de saúde em África é notável. O suprimento de sangue na África Subsaariana acarreta necessidades, desafios e busca de soluções. A transfusão de sangue está excecionalmente afetada nestes países, em consequência de uma tremenda pressão na fonte de sangue[22].

Os doadores de sangue são rotineiramente rastreados em todas as doações de sangue em muitas partes do continente africano onde cada colheita de unidade de sangue, passa por testes de triagem rigorosa para garantir segurança aos destinatários[25]. Mas existem ainda regiões em África em que a transfusão de sangue com segurança, continua a ser uma tarefa árdua por vários fatores desde a escassez, à má execução das diretrizes até às infraestruturas, fazem com que haja um aumento da prevalência de infeções de transmissão por transfusão de sangue e seus derivados, principalmente hepatite e VIH[26]. Em Angola foram realizados alguns estudos de prevalência que demonstraram uma seroprevalência de 8,8% para o VIH na população geral e 2,1% para o VIH em doadores de sangue[27], [28]. Fazem também referência à alta prevalência para o vírus da hepatite B com 9,3% para população geral e 8,5% entre os doadores de sangue[27], [28]. Em relação à coinfeção, a prevalência foi de 2,3% para VHB/VIH; 0,9% VHC/VIH; 0,9% para VHB/VHC e em menor percentagem para coinfeção da sífilis com restantes vírus[27]. Outro estudo realizado, em homens que têm relações sexuais com homens, mostrou uma seroprevalência para o VIH ajustada de 3,7%. Neste grupo a seroprevalência foi mais baixa do que o esperado[29]. Num estudo publicado em 1990, a seroprevalência global do VIH foi de 14,2% sendo mais alta nas províncias de Luanda, Lunda-Norte e Huambo[30]. Entretanto há necessidade de investigar as características sociodemográficas que estão associadas com ITT.

A Organização Mundial de Saúde (OMS) tem estado na vanguarda dos esforços, para que seja possível estabelecer serviços de transfusão de sangue seguros, disponíveis e acessíveis na maior parte de países africanos, através de incentivos, recrutamento adequado de doadores de sangue, rastreio e recolha de sangue de doadores, bem como desenvolvendo estratégias para o uso racional de sangue. Notou-se uma modesta melhoria, especialmente no que diz respeito à triagem do sangue do doador para as ITT mais comuns.

Breve História da Hemoterapia em Angola

Na sequência deste trabalho, aprouve uma breve história da hemoterapia em Angola. Angola é um país da África Austral com uma população de aproximadamente de 38 838 040 milhões de habitantes[31]. Faz fronteira a Norte e Nordeste com a República Democrática do Congo e Congo Brazzaville, a Leste com a Zâmbia, a Sul faz fronteira com a Namíbia e Botswana. A Oeste é banhada pelo Oceano Atlântico. Desde 1999, que novos métodos de rastreio envolvendo a amplificação de ácidos nucleicos (NAT) para detetar o VIH e VHC, foram aprovados pela Food

and Drug Administration (FDA)[32-34] mas impera a alta prevalência de VIH, VHB, VHC e sífilis que tem aumentado os problemas de segurança do sangue em algumas partes do mundo[35].

Com o surgimento da infeção pelo vírus de imunodeficiência humana desde 1980-1981 e a proliferação de doenças transmissíveis por transfusão sanguínea, surge a preocupação mundial sobre a segurança da transfusão de sangue. Na década 90 é aprovada em Angola, a política pública de sangue, com o surgimento de uma rede de centros de doação voluntária de sangue não remunerada, resultante da solidariedade. Todo este processo que envolve o processamento dos componentes sanguíneos foi incluído como política nacional e gratuita pelo Ministério da Saúde de Angola. Com estas políticas estruturaram-se ações e serviços de hemoterapia e etapas implicadas no processo. Assim, foram criados bancos de sangue nos hospitais, com base na lei da doação de sangue em Angola, para tratamento transfusional. A percentagem de doadores de sangue, atualmente em Angola, é inferior a 1% da população, sendo que 80% das transfusões de sangue são de doações familiares[36].

• Clínica Girassol

A Clínica Girassol é uma instituição de saúde subsidiária da Petrolífera Angolana Sonangol, empresa pública de Direito Angolano e foi inaugurada em 04 de setembro 2008. Presta assistência ao sistema nacional de saúde no atendimento terciário dos doentes. Após a sua inauguração, o Centro de Imunohemoterapia e Banco de Sangue, promoveu a sua atividade no que diz respeito à doação de sangue, cumprindo as regras nacionais. Após uma exaustiva preparação, seguindo todos os critérios e normas do sistema "International Organization for Standardization" (ISO) de certificação, o Centro de Imunohemoterapia e Banco de Sangue em 2014 conquistou o selo de certificação ISO 9000 e foi recertificado em 2021 pela Norma ISO 9001:2015. O esforço para conseguir doadores é o busílis dos pontos estratégicos mais importantes do Serviço de Imunohemoterapia, para garantir a quantidade e qualidade dos componentes necessários para a doação de sangue. A colheita de sangue é segura, de baixo custo, e o laboratório procede à análise de maneira automatizada, sendo a sua especificidade e sensibilidade elevadas, chegando a 90% e 98% respetivamente à identificação do marcador.

• Captação de doadores

Perante a carência de sangue, a necessidade da segurança no ato da transfusão, o aperfeiçoamento, o fortalecimento da cultura de doação voluntária e não remunerada de sangue, a estruturação da atividade de captação dos doadores nos serviços de sangue tornou-se num grande desafio. Nesta fase do processo de doação de sangue, são utilizados vários métodos para sensibilizar pessoas individualmente, ou no geral (envolvendo a família), sobre a importância e necessidade da doação de sangue, a fim de possibilitar tratamentos e procedimentos terapêuticos aos que necessitam.

Em Angola têm-se verificado um agravamento nos índices negativos de doação voluntária de sangue. Apenas 1% da população Angolana é doadora de sangue[36], há escassez e enormes necessidades.

A OMS preconiza que 3,5-5% da população deveria doar sangue, a cada ano, para a manutenção do stock de sangue e hemoderivados de cada país[37]. O cenário angolano está muito longe de ter reserva e manter um stock de sangue. Um dos aspetos que podem contribuir para a avaliação de ações de mobilização e sensibilização da população para a doação de sangue é, o de identificar as estratégias que estão a ser utilizadas para sensibilizar pessoas para doar, e os fatores motivacionais que podem incentivar este ato.

São potenciais doadores de sangue indivíduos com boas condições de saúde, com idade compreendidas entre os 18 aos 65 anos, com peso mínimo de 50 Kg e que não possuam impedimentos para a doação. Preferencialmente, os doadores não devem estar sob terapêutica antimicrobiana, efeito de álcool e outras condições como ser portador de patologia cardíaca, hematológica, infeciosa, gravidez e apresentar comportamentos de alto risco.

Etapas implicadas no processo sistemático de recolha de sangue

No âmbito das responsabilidades para a execução das etapas dos cuidados da colheita de sangue e organização a nível nacional, os serviços de sangue existentes em Angola de acordo com normas estabelecidas pela OMS, passaram a ter necessidade de estabelecer estratégias para a promoção da doação de sangue. O Instituto Nacional de Sangue da República de Angola coordena as atividades relacionadas ao ciclo de sangue e estabelece:

- O ciclo de sangue compreende e abrange as atividades de captação e seleção do doador, triagem clínico-epidemiológica (ver documento em anexo 4), colheita de sangue, triagem laboratorial das amostras de sangue, processamento, armazenamento, transporte, distribuição e procedimentos transfusionais e de hemovigilância[36].
- A bolsa de sangue totalmente coletada e tecnicamente em conformidade com a norma ISO, poderá ser processada para a obtenção de um ou mais componentes. Os mais utilizados atualmente na prática clínica são: concentrado de hemácias, concentrado de plaquetas, plasma fresco congelado, crioprecipitado e concentrado de granulócitos.

Para que haja segurança na oferta de todos estes componentes, a captação de doadores e sua triagem é de suma importância.

2 EPIDEMIOLOGIA

2. EPIDEMIOLOGIA

2.1. Considerações Gerais de Epidemiologia

Existe uma considerável variação na predominância da transmissão de infeções por transfusão sanguínea em diferentes áreas geográficas. Uma revisão realizada em África, com dados da OMS, obtidos através dos relatórios, sobre doadores de sangue, indica que existem variações no nível de melhoria de colheita de sangue e da segurança de sangue de uma área para outra, principalmente na área da motivação dos doadores ou estratégias de rastreio para infeções de transmissão transfusional[38].

Os doadores de sangue são rotineiramente rastreados para hepatite B com AgHBs, razão pela qual houve um decréscimo da incidência da transmissão, mas o risco de adquirir infeção pós transfusional depende de vários fatores, sendo um deles a estratégia de realizar o teste no doador. A falta de recursos, a escassez crónica de sangue em África, acarreta a alta prevalência de transmissão de agentes infeciosos, no que se refere a segurança da transfusão sanguínea [22, 23] [39]. África Subsaariana, Ásia, região do Pacífico e América do Sul[1] apresentam alta prevalência da hepatite B, hepatite C, VIH e sífilis. Muitos desses países em desenvolvimento continuam a ter acesso limitado a medicamentos essenciais. Angola está entre os muitos países subdesenvolvidos que carece de melhoria na assistência médica e onde a doação de sangue ainda é escassa com dificuldade na reserva de sangue para suprir as necessidades que o país apresenta. Nesta ordem de ideias, surge a necessidade e o desafio de realizar estudos. Como resultados deste projeto de pesquisa e, devido às diferenças clínicas e epidemiológicas de cada entidade patológica, foi realizado o primeiro estudo que consiste numa Revisão Sistemática e Meta-análise intitulada **"Prevalence of Serologic Markers of Hepatitis B Virus, Hepatitis C Virus, Human Immunodeficiency Virus and Syphilis in Blood Donors in African Countries: A Systematic Review and Meta-analysis"**. Este estudo teve como alvo, analisar, conhecer e ter uma visão global da seroprevalência dos marcadores serológicos da Hepatite B, Hepatite C, Vírus de Imunodeficiência Humana e Sífilis dos 54 países africanos. Atendendo à extensão do trabalho, foi decidido separar em 4 Revisões Sistemáticas com Meta-análise que serão descritos ao longo da tese, em função do título de cada marcador serológico.

2.1.1. A Hepatite B

Dados históricos demostram que cinco vírus hepatotrópicos, foram descobertos entre 1963 e 1989, que são as principais causas de hepatites virais em todo o mundo, o vírus

da hepatite A (VHA), vírus da hepatite B (VHB), vírus da hepatite C (VHC), vírus Delta da hepatite B e vírus da hepatite E (VHE). A sua epidemiologia e patogénese têm sido estudadas com grande detalhe[47]. Baruc Blumberg[48], em 1965, quando procurava marcadores tumorais no sangue de um australiano, detetou um antigénio invulgar. Este antigénio, reagia com o sangue de um doente com leucemia que tinha sido submetido a várias transfusões[48],[49],[50]. Os soros de doentes em fase de convalescença da hepatite, que reagiam com este antigénio, permitiram identificar o chamado "antigénio Austrália", reconhecido posteriormente com sendo a proteína do invólucro do vírus da hepatite B e passou a chamar-se antigénio de superfície do vírus da hepatite B (AgHBs)[48]. Com isso, foi possível elaborar testes de deteção do VHB no sangue, permitindo identificar os portadores do agente em fase aguda ou crónica e com a utilização destes exames o rastreio dos doadores de sangue se tornou possível, bem como a redução do número de casos de hepatite pós transfusional. A hepatite viral tipo B afeta mais de 320 milhões de pessoas globalmente, levando a morbimortalidade significativa devido à insuficiência hepática e carcinoma hepatocelular (HCC)[40], [41]. A OMS estima que mais de 350 milhões de pessoas em todo o mundo são portadores crónicos do vírus da hepatite B (VHB), [42] e, mais de 700.000 óbitos foram diretamente atribuíveis ao VHB[43]. Em todo mundo, mais de 250 milhões de pessoas, estão cronicamente infetadas, com o risco de desenvolver hepatocarcinoma[44] sendo que por ano, 2-5% de pessoas infetadas pelo vírus da hepatite B desenvolvem hepatocarcinoma, independentemente da cirrose. Em 2022, a prevalência global estimada de infeção pelo VHB foi de 3,2% [95% IC: 2.7%-4.0%], que corresponde a 257,5 milhões de indivíduos portadores de AgHBs[45], o que torna a infeção, uma das mais importantes doenças infeciosas a nível mundial. A taxa de progressão da infeção da forma aguda para crónica, varia, isto é, diminui com a idade. Aproximadamente 90% da infeção é adquirida na fase perinatal e as mais baixas 5% na idade adulta[46].

A variação da prevalência do AgHBs pode ser atribuída a muitos fatores, incluindo as condições socioeconómicas em que as pessoas vivem, a idade, sexo, a constituição genética da população e o risco de exposição.

A Europa Ocidental (com alguma variação dentro da Europa), Estados Unidos da América, Canadá, Austrália e Nova Zelândia, são áreas de baixa prevalência (0,1-2%), países do Mediterrâneo, Japão, Ásia Central, Médio Oriente, América Latina e Sul de América com prevalência intermédia (3-5%) e áreas com elevada prevalência (10-20%) Sul da Ásia, China e África subsaariana. No global a prevalência do VHB varia de 0,20% a 22,38%[52].

Uma análise retrospetiva, realizada em França, sobre o rastreio serológico da hepatite B (serologias para AgHBs, AcHBs e AcHBc), no centro de vacinação do Instituto Pasteur, demostrou que a prevalência da infeção pelo vírus da hepatite B foi de 5,86% e a seroprevalência de pessoas de origem de África-Subsaariana foi de 9,2%, mais elevada do que nos outros grupos geográficos. A seroprevalência para o vírus da hepatite B, devido ao grande número de migrantes, foi maior do que no geral da população francesa e europeia[55]. No Benim, em 2011, foi realizado um estudo onde avaliaram a prevalência dos marcadores serológicos em 283 gestantes submetidas ao rastreio, que viviam numa área rural do Norte de

Benin, tendo sido comparados os dados com os reportados em 1986. Em comparação com este ano 1986 chegaram à conclusão de que a prevalência manteve-se inalterada para o AgHBs e anti-HBc (AgHBs com 15,5%, anti-HBc 82,7%) e elevada para anti-VHC com 7,4% e 3,2% para o anti-HIV 1 e 2 positivo[59].

Na Namíbia, dados retirados do Instituto Central de Patologia do Laboratório de Namíbia em Windhoek durante janeiro-dezembro 2013, demonstrou que de um total de 77238 resultados de testes realizados para rastreio do antígeno de superfície do vírus da hepatite B em todo o país, foi de 9087 (11,8%) positivos. Dos resultados positivos, 246/9087 (2,7%) eram crianças com idades compreendidas dos 0-14 anos, em ambos os sexos. As infeções pelo VHB aumentaram acentuadamente, particularmente entre as mulheres da faixa etária dos 15-39 anos, atingindo um pico no grupo etário de 30-34 anos[60]. Um estudo descritivo sobre a prevalência dos marcadores serológicos de hepatite B, C e D em migrantes africanos, realizado em Espanha, mostrou que a hepatite viral continua a ser um problema de saúde significativo em países africanos e representa um desafio para o sistema de saúde espanhol. O estudo incluiu 2518 doentes (87,7% de nativos do Saara), com uma idade média de 31,3 anos. Cerca de 78,8% dos doentes apresentaram positividade para o AgHBs. Sessenta e oito (68) doentes apresentaram anticorpos contra o vírus da hepatite C, dos quais 26 tinham uma carga viral positiva[53]. No Haiti, a prevalência dos doadores de sangue foi de 3,80% para o antigénio de superfície do vírus da hepatite B e 0,56% para o anticorpo VHC[54]. Os resultados do nosso estudo não estão muito distantes da realidade espanhola encontrada na população imigrante oriunda da África subsaariana. Foi incluído no nosso estudo um total de 2734 doadores de sangue com idades compreendidas entre 18 e 64 anos (32±9) e a seroprevalência do AgHBs (marcador positivo para o vírus da hepatite B) foi de 1373 (50,2%), neste estudo realizado na Clínica Girassol, em doadores de sangue, conforme se verifica na publicação 1 que seguidamente se apresenta também na publicação 6.

A situação relativamente à prevalência da infeção pelo vírus da hepatite B em África é alarmante. A título de exemplo, dentro da região de África, na Nigéria, o risco médio de contrair a hepatite B, entre os nigerianos é desconhecido. Uma revisão sistemática e meta-análise realizada na Nigéria de 2000 a 2013 incluiu 46 estudos (n=34,376 pessoas), mostrou uma prevalência de VHB de 13,6% [95% IC: 11,5% a 15,7%][56]. A Mauritânia é também considerada uma área altamente endémica para o vírus da hepatite B[57]. Outra revisão sistemática realizada em 2018 mostra uma alta prevalência de todas as formas de hepatite viral na Somália e também os autores referiram que a hepatite B crónica, foi a causa mais comum de doença hepática crónica, sendo a prevalência total do VHB de 18,9% [95% IC: 14% a 29%] e a do VHC foi estimada em 4,84% [95% IC: 3, 2% a 7,67%][58].

Ter conhecimento da prevalência das infeções de transmissão transfusional é de uma mais-valia para intervenções de planeamento eficaz e criterioso de recursos para suprir as necessidades do défice de sangue sem infeções, um desafio, mas que é possível. A revisão sistemática e meta-análise que se segue, teve como aplicação analisar, conhecer a seroprevalência dos marcadores serológicos do vírus da Hepatite B dos 54 países africanos. Dos países incluídos no nosso estudo da revisão sistemática e meta-análise, encontramos uma seroprevalência de 6,93% (95% CI:5,95-7,97%; I^2=100% p<0,001), conforme se verifica no estudo que seguidamente se apresenta.

2.1.2 - A Hepatite C

Um outro agente infecioso responsável pelos casos da hepatite não-A e não-B, já se suspeitava da sua existência em 1975 e pela primeira vez em 1989, foi usado o termo vírus da hepatite C (VHC), após a identificação de um genoma de ácido ribonucleico (ARN). A hepatite não-A e não-B foi anteriormente identificada como hepatite que ocorria após transfusão de sangue, hemoderivados ou uso de drogas intravenosas[51].
A hepatite C é um outro problema de saúde pública que lidera a doença hepática crónica e a imigração, assim como a globalização, contribuíram para o aumento desta doença[61].

Ao longo destes últimos anos, a hepatite C surgiu, como uma das causas mais significativas da doença hepática crónica em todo o mundo, com uma prevalência estimada que varia de 2,2 a 3,0%. É uma das principais causas de morbimortalidade relacionadas com o fígado em todo o mundo[62]. A OMS estima que mais de 250 milhões de pessoas em todo o mundo têm anticorpo positivo para o vírus da hepatite C[41], sendo que 80 milhões de pessoas (1,1% globalmente) estão infetadas cronicamente com este vírus[40]. Pessoas infetadas pelo VHC com fibrose avançada 1-5% desenvolvem carcinoma hepatocelular [63]. A mortalidade relacionada ao vírus da hepatite C (morte por insuficiência hepática ou carcinoma hepatocelular) aumentou nos últimos anos[64].

A prevalência do vírus da hepatite C varia substancialmente em todo mundo. O vírus da hepatite C é também um vírus importante de ITT[61] e estima-se que a prevalência permaneça elevada na Ásia Central e Oriental, Norte de África, Região do Médio Oriente, sendo superior a 3,5%; Sul e Sudeste Asiático, África Subsaariana, região central e sul da América Latina, Caribe, Oceânia, Europa Central, Oriental e Ocidental têm prevalência moderada com 1,5%-3,5%. Foi considerada baixa prevalência o Pacífico-Ásia, América Latina Tropical e América do Norte com prevalências menor que 1,5%[65, 66].

A grande maioria de indivíduos portadores do vírus da hepatite C não é diagnosticada ou tratada, sendo uma das causas de doença hepática crónica e hepatocarcinoma especialmente no continente africano onde a prevalência permanece alta, mas incerta. Dos indivíduos infetados no mundo inteiro pelo vírus da hepatite C, 90% vivem em condições limitadas de recursos[67-71].

Em 2023, de acordo com a OMS, 3% da população mundial está infetado pelo VHC, que corresponde a 170 milhões de pessoas em todo mundo e o continente africano foi o que apresentou maior prevalência de VHC com 7,1% (IC 95%: 4,4%-11,5%)[72]. Estima-se que aproximadamente 250.000 indivíduos no Canadá estão infetados pelo VHC e 5000 canadienses, a cada ano, são infetados[73]. Aproximadamente 2% dos indivíduos em Itália estão infetados com VHC[9]. No México, de acordo com o serviço nacional de saúde, no ano 2000 estimou-se mais de 70000 casos. Um estudo aí realizado, mostrou uma prevalência de 1,3%, tendo sido considerado um país com menor prevalência de VHC em relação aos países desenvolvidos e de outras áreas endêmicas[74]. Uma das maiores taxas de prevalência do vírus da hepatite C no mundo, encontra-se no Egipto, sendo o genótipo 4, o mais prevalente e que está altamente associado à fibrose severa e consequentemente, o carcinoma hepatocelular tornou-se a principal causa de cancro nesse país[57]. Para atingir os objetivos preconizados pela OMS, relativamente à eliminação do VHC em 2030, dados

atualizados de boa qualidade sobre a epidemiologia do VHC são necessários, principalmente para as populações-chave, nomeadamente utilizadores de drogas endovenosas e homens que praticam sexo com homens[75]. Na Nigéria, foi realizado um estudo, sobre hepatite C em 2 comunidades remotas, entre os indígenas no centro-norte do país, onde se evidenciou que 15% da população apresentou marcadores serológicos de infeção do vírus da hepatite C[76].

Em África o uso de agulhas para tratamento médico e transfusão de sangue podem ser os principais modos de transmissão, enquanto na Europa, Ásia, América do Sul e Central, a maioria das transmissões ocorrem através do uso de drogas ilícitas[78]. Cinco a 12% dos doentes que recebem transfusão de sangue desenvolvem hepatite[38]. A OMS tem como meta atingir uma redução de 65% em óbitos relacionados com doença hepática e uma redução de 90% de novas infeções virais da hepatite até 2030[79]. A prevalência encontrada no nosso estudo do anticorpo do vírus da hepatite C em doadores de sangue foi de 140(5,1%) como se pode ver na publicação 1 e 6.

Revisões recentes sobre a prevalência global do vírus da Hepatite C com base no número de pessoas com anti-VHC positivo, tem mostrado que estes aumentaram de 2,3% para 2,8%, isto é, mais de 122 milhões para números superiores a 185 milhões entre 1990 e 2005. Portanto, são indivíduos em risco de desenvolver cirrose hepática e cancro do fígado[65]. Uma revisão sistemática, que engloba os países do Norte de África e Médio Oriente, mostrou que a maioria dos países desta região tem prevalência do VHC baixa a moderada.

Outra revisão sistemática publicada em 2016 avaliou a seroprevalência do VHC realizada em 38 países. A seguir ao Egipto, onde se destaca claramente, os mais altos níveis de seroprevalência, foram também encontrados na África Central (Camarões, Gabão e Angola) e alguns países da África Ocidental (Burkina Faso, Benin). O maior número absoluto de adultos infetados foram encontrados na Nigéria, Etiópia e República Democrática do Congo. Dados de vírus da hepatite C do sul de África estão incompletos, uma vez que pouca pesquisa foi publicada para países como Angola e Namíbia. Países da África Central e Sul mostram uma prevalência de VHC de <1% para > 10%[77].

A revisão sistemática e meta-análise por nós realizada demostra uma seroprevalência do vírus da hepatite C em doadores de sangue africanos de 2,46% (95% CI:1,97%-3,00%; I^2=100% p<0,01), como se pode verificar no trabalho que se segue.

2.1.3. Vírus de imunodeficiência Humana (VIH)

O Vírus de Imunodeficiência Humana (VIH) permanece desde a sua identificação nos anos 80, como um agente infecioso que assola e preocupa a humanidade afetando mais de 39 milhões de pessoas globalmente e a maioria vive em África, onde 1 indivíduo em cada 30 está infetado[80]. Na história da humanidade o VIH, foi a doença que teve impacto na medicina.

Investigadores referem que o vírus existe em zonas rurais de África há mais de 150 anos sendo a infeção por VIH-2 endémica, apenas em África Ocidental. Desconhece-se o que se passou em África antes de 1959, mas é sabido que entre 1966 e 1977, foi identificado o anticorpo-VIH-2, em amostras de sangue colhidas em países de África Ocidental e também identificado o anticorpo-VIH-1, no sangue colhido em indivíduos na República Democrática do Congo em 1959[81]. Não se sabe ao certo a idade do vírus nem quando ocorreu o primeiro caso de SIDA, mas a doença como entidade clínica distinta foi reconhecida pela primeira vez em 1981[81]. O vírus foi inicialmente identificado em utilizadores de drogas endovenosas e em hemofílicos, mais tarde, foi identificada em recetores de transfusões de sangue em adultos da África Central e crianças nascidas de mães com SIDA. Com a utilização de soro congelado de doentes que morreram no passado com causa desconhecida, foi possível com o *Enzyme-Linked Immunosorbent Assay* (ELISA) e ou *Western blot* (técnica de identificação de anticorpos de agentes infeciosos) encontrar os primeiros casos de indivíduos que morreram de SIDA, em França, na Bélgica no final dos anos 70 e início dos anos 80, que tiveram estadia em África[84].

A prevalência da infeção pelo VIH em África varia de uma região para outra e as taxas de prevalência do VIH diminuíram após a implementação das políticas de segurança nos doadores de sangue[82]. E apesar da seleção de produtos de sangue, a transfusão de sangue ainda é responsável por 5 a 10% da infeção pelo VIH na África Austral.

Aproximadamente 71% dos indivíduos infetados pelo VIH vivem na África Subsaariana[87]. Estudos realizados têm demostrado maior prevalência de VIH na população Africana[88]. Na África do Sul e República Centro-Africana foi respetivamente de 0,10 a 15% em novos doadores em 2004[38]. Guiné-Bissau foi o país onde foi encontrada a maior seroprevalência de infeção por VIH-2 chegando a ser de 13,2% na população em geral. Países com ligação forte com este país, como Angola, Brasil, Moçambique, Sudoeste da Índia e Portugal, também apresentam um padrão epidemiológico, diferente de outras partes em relação a prevalência do VIH-2.

Um estudo, sobre prevalência dos marcadores serológicos, realizado no Reino Unido, mostrou que a prevalência do VIH é mais elevada em militares de origem africana, do que nos militares do Reino Unido[89]. Estudo de prevalência sobre marcadores serológicos, realizado em Granada-Espanha em mulheres grávidas imigrantes e espanholas, mostrou que 11,8% das mulheres oriundas de África Subsaariana e 1% de mulheres oriundas do norte de África apresentaram, maior prevalência do VIH[90], facto que contribuiu para o aumento e mudança de prevalência de marcadores serológicos de rotina em gestantes ao longo dos anos, da população feminina daquele país, fruto da imigração de países menos desenvolvidos para a Espanha. Outro estudo realizado nesse mesmo país em imigrantes trabalhadoras do sexo, demostrou que 762 das trabalhadoras do sexo imigrantes (75,3%) eram

oriundas da África Subsaariana. A seroprevalência do VIH entre africanos e equatorianos foi de 4,5 e 10,9%, respetivamente e todos os VIH-1 positivos equatorianos eram homens transexuais, e 28,6% tinham infeção ativa por sífilis. Nenhum deles foi reativo para anticorpo VIH-2[91].

O nosso estudo observacional, revelou uma seroprevalência de infeção pelo vírus de imunodeficiência humana em doadores de sangue da Clínica Girassol de 191(7%). Esses dados podem ser verificados na publicação 1 e 7.

Uma revisão sistemática que incluiu 24 países da União Europeia estimou que a aquisição do VIH foi de 2% na Suíça, entre os africanos oriundos da África Subsaariana e 62% entre os homens negros do Caribe que têm contacto sexual com homens têm VIH[92]. Dito isto, a SIDA permanece sendo um flagelo, que pode afligir indiscriminadamente toda a população mundial.

O nosso trabalho, resultou na terceira revisão sistemática e meta-análise, que é apresentada a seguir e os resultados demostram uma seroprevalência de 2,66% (95% CI:2,17-3,20%; I^2=99,80% p<0,001) do vírus de imunodeficiência humana em doadores de sangue africanos, como se pode verificar no artigo que se segue.

2.1.4. Sífilis

Na África subsaariana, a sífilis, segue sendo um dos problemas graves de saúde pública. É uma doença causada por uma bactéria anaeróbia-espiroqueta denominada *Treponema pallidum ssp*, que é dividida em diferentes estágios e transmitida principalmente por contato sexual de uma pessoa infetada através da inoculação da mucosa[93]. A transfusão sanguínea é outra via de infeção e, embora o risco transfusional da sífilis seja muito baixo, recomenda-se o rastreio[94].

Está relatado que a sífilis era uma doença desconhecida até ao dia quatro de março de 1493, altura em que Cristóvão Colombo levou consigo 3 pequenas embarcações com 120 homens[98]. A doença foi chamada de serpentina como repugnante, feia, assustadora e se transmitia por contato sexual. Assim, se espalhou a sífilis pela Europa (Itália, Sul de França, Alemanha, Portugal) e Américas[98], [99].

No ano de 1905, a comunidade científica propôs para o microrganismo espiralado de *"Treponema pallidum"* ("*Treponema*" por causa da sua semelhança com um fio torcido, e "*pallidum*", por causa da sua cor)[100]. Em 1946 foi desenvolvido o teste mais utilizado nos dias de hoje denominado *Veneral Disease Research Laboratory* (VDRL) que deteta anticorpos não específicos do treponema.

De doença rara na década de 50, disseminou-se a partir da década de 80 devido a um aumento da sífilis e deve-se ao fato de ter recuperado espaço na comunidade de homens que têm relações sexuais com homens e a um aumento generalizado nos últimos anos incluindo em África[95]. De acordo a OMS, em África, o risco de contrair sífilis através da transfusão de sangue foi de 0,48%, razão pela qual, a OMS[96], implementou medidas padrão para transfusão segura de sangue, nomeadamente triagem universal para *Treponema pallidum* e testes rápidos de diagnóstico têm sido amplamente adotados em países em desenvolvimento. Rotineiramente é feito o rastreio de todos os doadores de sangue, em muitas partes de África, passando por rigorosos testes de triagem para garantir a segurança do recetor[97].

Embora seja pouco descrita, diagnosticada e igualmente pouca estudada, a sífilis é um grave problema de doença negligenciada no continente africano, merecendo um debruçar mais acutilante da OMS sobre esta patologia.

Os resultados do estudo observacional de prevalência realizado na Clínica Girassol demostram uma seroprevalência de 436 (20%), com se pode verificar nas publicações 1 e 8.

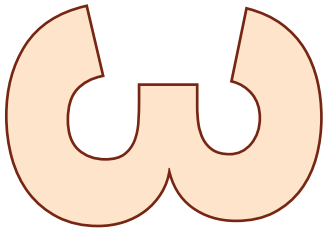
A revisão sistemática e meta-análise que se segue, revela uma seroprevalência de 2,47% (95% CI:1,81-3,24; I^2=100%, p<0,01) dos marcadores serológicos da sífilis em doadores de sangue nos países africanos.

2.1.5. Coinfeção

A coinfeção pelo vírus da hepatite C, vírus da hepatite B, vírus de imunodeficiência humana e sífilis, pode ser encontrada em países endémicos, principalmente em África, onde a prevalência destes vírus é alta. A coinfeção também pode ser encontrada em populações de risco de transmissão parenteral principalmente na coinfeção VHB/VHC. Estudos prévios demonstraram alto risco de progressão da doença hepática em doentes com coinfeção VHB/ VHC pelo que devem ser tratados agressivamente, com terapêutica combinada e monitorização regular, uma vez que o risco de desenvolver cirrose hepática e carcinoma hepatocelular é alto quando comparado com doentes monoinfetados. A doença hepática crónica em fase terminal, como resultado da coinfeção com o vírus da hepatite B e ou C, é também uma das principais causas de morte principalmente se estes indivíduos estão infetados com o vírus de imunodeficiência humana[110]. Um estudo descritivo realizado no Egipto, demonstrou que 14% dos doentes coinfetados pelo vírus da hepatite B que tinham cirrose, dois deles desenvolveram hepatocarcinoma, quando comparado com 9% de doentes monoinfetados pelo VHC, não desenvolveram cancro do fígado[111]. A coinfeção está associada a uma maior morbimortalidade e maior utilização dos recursos de cuidados de saúde. Uma estimativa precisa da prevalência da coinfeção VHB/VHC e VIH é necessária para tomar decisões políticas e planear intervenções comunitárias de saúde.

No continente africano, a prevalência de ambas infeções é desconhecida, mas alguns autores estimam uma prevalência de aproximadamente 5%-20% em doentes com coinfeção VHB/VHC, com distribuição geográfica bastante variada. Um estudo descritivo e uma revisão sistemática de autores indianos, demonstraram uma seroprevalência de 0,07% de coinfeção de AgHBs e anti-VHC [4], e uma prevalência combinada da coinfeção VHB/VHC de 1,89%; VIH/VHC de 13,2%. Uma coorte realizada por autores vietnamitas e revisão sistemática realizado no Vietname demostrou que da coorte de doadores de sangue com VIH positivo, 12,1% apresentaram AgHBs positivo e 39,2% anticorpo VHC positivo[112]. Apesar da transmissão destas infeções serem comuns, existem diferenças regionais na transmissão e variam, representando um desafio para a saúde pública, principalmente em África onde vive a maioria de pessoas infetadas e com recursos muito limitados. Isto representa um grande peso nos serviços de saúde locais e enfatiza a necessidade urgente de recursos a nível global, especialmente em África[113].

Há necessidade de melhorar os programas para consciencialização e assim reduzir a progressão das doenças porque a incapacidade de o fazer resultará num aumento da mortalidade, diminuindo a sobrevivência atribuída ao tratamento generalizado das coinfeções, principalmente pelo vírus de imunodeficiência humana. Relativamente à coinfeção com a sífilis torna-se acessível o controlo, uma vez que, cumprindo o tratamento correto em função do estadio da sífilis, a cura é garantida. Os indivíduos coinfetados por esses agentes (VHB, VHC, VIH e sífilis) devem ser examinados, monitorizados e tratados para outras infeções que possam existir. O controlo otimizado e a melhoria da cobertura da vacinação no caso do vírus da hepatite B proporcionam a melhor prevenção. O estudo de prevalência, realizado numa Clínica em Luanda, demonstrou uma incidência de coinfeção de 2,3% para VHB/VIH, alertando para a qualidade de sangue doado[27]. O nosso estudo, realizado na Clínica Girassol, encontrou uma seroprevalência de 5,9% de indivíduos coinfetados sendo a coinfeção mais prevalente o VHB e sífilis. A coinfeção está também descrita e espelhada na Publicação 1.



OBJETIVOS E MÉTODOS

3. OBJETIVOS E MÉTODOS

3.1. Objetivos

O grande aumento das infeções de hepatite B, hepatite C, VIH e sífilis na população mundial e principalmente em África, faz com que aumente a preocupação de avaliação dos marcadores de infeção em doadores de sangue. Daí o nosso **objetivo geral** ser o de identificar a prevalência dos marcadores serológicos da hepatite B, hepatite C, vírus de imunodeficiência humana e sífilis em doadores de sangue da Clínica Girassol e nas regiões de África.

Atendendo ao envolvimento da comunidade na doação de sangue e tendo em consideração a complexidade das instituições, o aumento de acidentes de viação e a grande necessidade de sangue, surge a pertinência e relevância de responder à questão de pesquisa. Assim sendo, a pesquisa, acaba por levantar uma hipótese pertinente, que é:

Qual é a prevalência dos marcadores da hepatite B e C; VIH; sífilis e a coinfeção, dos doadores de sangue da Clínica Girassol?

Entretanto, os **objetivos específicos** deste projeto foram definidos:

- Identificar a seroprevalência de marcadores com resultados positivos para a hepatite B, hepatite C, VIH, sífilis e coinfeção em doadores de sangue da Clínica Girassol, Luanda-Angola;
- Demonstrar potenciais coinfeções em doadores de sangue da Clínica Girassol, Luanda-Angola.

3.2. Métodos

Procedimento Geral

• Revisão sistemática e meta-análise (Estudo secundário de estudos primários)

Procurou-se sempre conhecer aprofundadamente a prevalência dos marcadores da hepatite B, C, VIH e sífilis para enriquecimento e combate em termos de medidas profiláticas, que é de suma importância para dispormos de informação credível e aprofundarmos o conhecimento epidemiológico do doador na região de África. Usou-se um metódo base de evidências científicas para obtermos respostas às questões específicas. Para a revisão sistemática foi realizada recolha de dados em bases de dados indexadas nomeadamente *Scopus, Web-Science, MEDLINE/PubMed, WHO research database-HINARI, The Cochrane Collaboration, Clinical of Trials.gov, Global Index Medicus, African Journals Online (AJOL), Google Scholar.*

As referências obtidas foram identificadas e coordenadas através do programa EndNote. Artigos

de revistas eram identificados e primeiramente lidos e catalogados, após análise de seus dados e níveis de evidência científica.

- Local do Estudo: Departamento de Medicina Comunitária, Informação e Ciências de Decisão em Saúde (MEDCIDS) e Centro de Tecnologia da Saúde e Serviços de Investigação (CINTESIS) da Faculdade de Medicina da Universidade do Porto.
- Tipo de Estudo: Revisão Sistemática e Meta-análise.
- População: Todos os estudos primários, artigos completos publicados em qualquer idioma desde os primórdios até 1 de março de 2024.

• Estudo Descritivo Observacional de Prevalência

A presente pesquisa, estudo descritivo observacional retrospetivo de prevalência faz parte da análise de registos de doações de sangue efetuadas por doadores novos e regulares do banco de sangue e Serviço de Imunohemoterapia da Clínica Girassol em Luanda de 14 de janeiro de 2011 a 30 de junho de 2016. Este estudo foi aprovado pelo Comitê de Ética do Ministério da Saúde da República de Angola e também foi submetido a aprovação à Comissão de Ética para a Saúde do Centro Hospitalar de São João/Faculdade de Medicina da Universidade do Porto. Todos os doadores de sangue eram voluntários saudáveis e não remunerados (VNR). Foi realizada uma entrevista após consentimento livre e informado e preenchido um instrumento de colheita de dados, antes da doação de sangue. Todos os indivíduos que concordaram em doar sangue, deram e assinaram o termo de consentimento livre e esclarecido antes da colheita, (Referência FOCHBS0065, constando nos anexos desta tese) e analisada posteriormente de forma anónima. Em ambiente hospitalar, a interação com os participantes foi realizada exclusivamente por funcionários do serviço habilitados para realização do teste. O sigilo das informações extraídas dos registos dos participantes e, do registo dos dados pessoais, foi preservado. Os dados extraídos foram protegidos e disponibilizados apenas a investigadora principal do estudo.

- Local do Estudo: Serviço de Imunohemoterapia e Banco de Sangue da Clínica Girassol.
- Tipo de Estudo: Estudo Descritivo Observacional de Prevalência.
- População: Todos os doadores do Banco de Sangue e do Serviço de Imunohemoterapia da Clínica Girassol, no período de 14 de janeiro de 2011 a 30 de junho de 2016

Desenho do estudo

• Revisão sistemática e meta-análise

Este estudo é uma revisão sistemática e meta-análise intitulada **"Prevalence of Serologic Markers of Hepatitis B Virus, Hepatitis C Virus, Human Immunodeficiency Virus and Syphilis in Blood Donors in African Countries: A Systematic Review and Meta-analysis,"** baseada em *"The Preferred Reporting Items for Systematic Reviews and Meta-Analysis"* (PRISMA Statement Guideline updated in 2020[114] ver Figura 1. O protocolo do estudo foi registrado na PROSPERO com o número CRD42023395616.

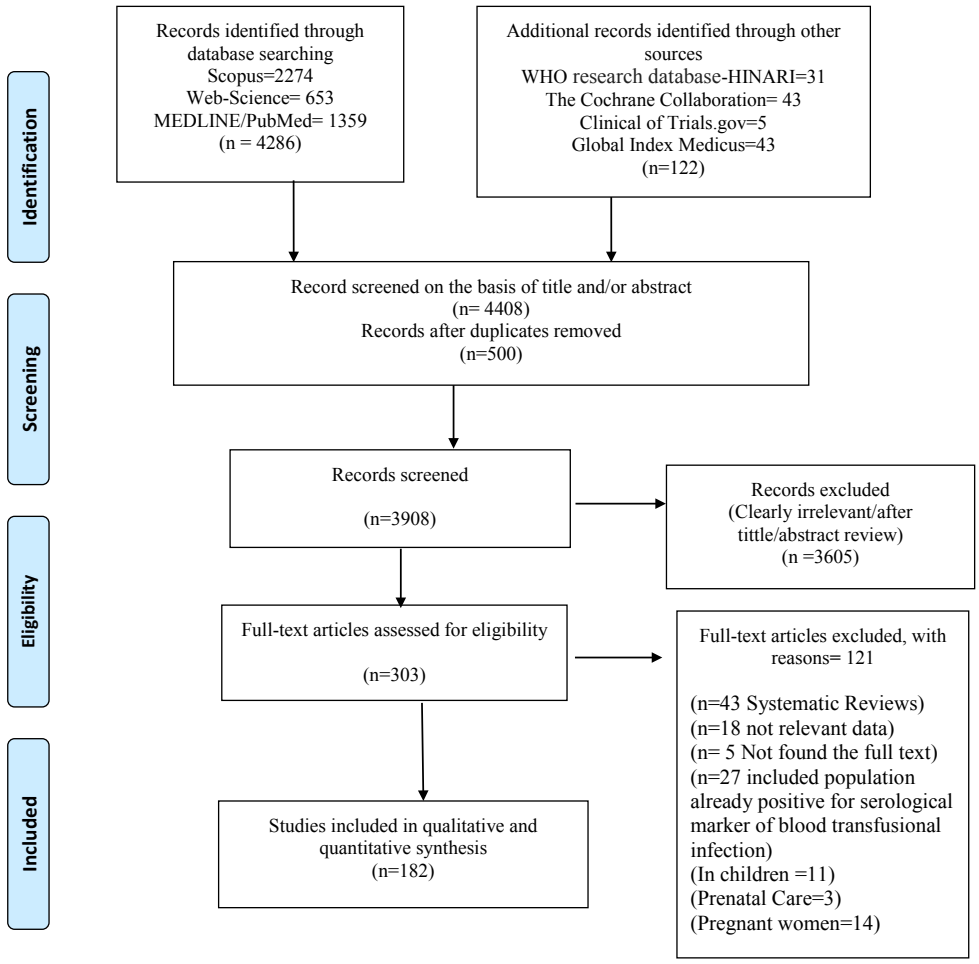


Figura-1: PRISMA Statement Guideline updated in 2020.

Seleção de estudos/participantes, estratégia de pesquisa e extração de dados

• Revisão Sistemática e Meta-Análise

Foram incluídos estudos primários com artigos completos publicados em qualquer idioma desde os primórdios até 1 de março de 2024, com título **"Prevalence of Serologic Markers of Hepatitis B Virus, Hepatitis C Virus, Human Immunodeficiency Virus and Syphilis in Blood Donors in African Countries"** com idades compreendidas entre 16 e 65 anos. Foram excluídas séries de casos, resenhas, comentários, cartas editoriais e estudos com dados duplicados. Todos os artigos relevantes foram pesquisados em bases de dados eletrónicas: *PubMed/ MEDLINE, SCOPUS, Web of Science*, base de dados de pesquisa da *WHO research database - HINARI*, biblioteca de bases de dados *The Cochrane Collaboration (Cochrane database library), Clinical Trials.gov, Global Index Medicus, African Journals Online (AJOL), Google Scholar* e manualmente através das referências dos artigos incluídos. A consulta de pesquisa pode ser observada na tabela abaixo e os termos principais de marcadores víricos muito utilizados nos trabalhos eram combinados com termos MeSH.

Tabela 1: Principais termos de marcadores víricos utilizados na pesquisa e combinados com termos MeSH.

Search	Query
#12	Search: #9 OR #4 AND #5 OR #6 AND #7
#11	Search: #9 AND #10
#10	Search: #4 OR #5 OR #6 OR #7
#9	Search: #8 AND #3
#8	Search: #1 AND #2
#7	Search: ((Syphilis OR Lues))
#6	Search: ((Hepaciviruses OR (Hepatitis C Virus OR Hepatitis C viruses) OR (Hepatitis C-Like Virus OR Hepatitis C-Like Viruses))
#5	Search: ((Hepatitis B virus OR Hepatitis B viruses) OR (Dane Particle OR Particle Dane) OR (Hepatitis Virus OR Homologous Serum))
#4	Search: ((HIV OR Human Immunodeficiency Virus OR Human Immunodeficiency Viruses) OR (AIDS Virus OR AIDS Viruses) OR (Acquired Immune Deficiency Syndrome Virus OR Acquired Immunodeficiency Syndrome Virus) OR (Human T Lymphotropic Virus Type III OR Human T-Lymphotropic Virus Type III) OR (Lymphadenopathy-Associated Virus OR Lymphadenopathy Associated Virus OR Lymphadenopathy-Associated Viruses) OR (HTLV-III OR LAV-HTLV-III))
#3	Search: Algeria OR Angola OR ((Benin OR (Republic of Benin) OR Dahomey)) OR (Botswana OR Bechuanaland OR Kalahari) OR ((Burkina Faso OR (Upper Volta) OR (Burkina Fasso)) OR ((Burundi OR (Republic of Burundi) OR Urundi)) OR ((Cabo Verde) OR (Republic of Cape Verde) OR (Cape Verde)) OR ((Cameroon OR (Republic of Cameron) OR (United Republic of Cameroon) OR Cameroons)) OR ((Central African Republic) OR Ubangi-Shari) OR Chad OR ((Comoros OR (Iles Comores) OR (Comoro Islands) OR Mayotte)) OR ((Democratic Republic of Congo) OR Congo OR (Kinshasa) OR Zaire OR (Belgian Congo) OR Katanga)) OR ((Republic of Congo OR Republic of the Congo OR Congo (Brazzaville)) OR ((Cote d'Ivoire OR (Ivory Coast) OR (Republic of Cote dilvoire)) OR ((Djibouti OR (Republic of Djibouti) OR (French Somaliland)) OR ((Egypt OR (Arab Republic of Egypt) OR (United Arab Republic)) OR ((Equatorial Guinea OR (Republic of Equatorial Guinea) OR (Spanish Guinea) OR (Guinea Spanish) OR (Rio Muni)) OR Eritrea OR (Eswatini OR Swaziland) OR ((Ethiopia OR (Federal Democratic Republic of Ethiopia)) OR ((Gabon OR (Gabonese Republic)) OR ((Gambia OR (Republic of the Gambia)) OR ((Ghana OR (Republic of Ghana) OR (Gold Coast)) OR ((Guinea OR (Republic of Guinea) OR (French Guinea)) OR ((Guinea-Bissau OR (Republic of Guinea-Bissau) OR (Portuguese Guinea)) OR ((Kenya OR (Republic of Kenya)) OR ((Lesotho OR Basutoland OR (Kingdom of Lesotho)) OR ((Liberia OR (Republic of Liberia)) OR Libya OR ((Madagascar OR (Malagasy Republic)) OR ((Malawi OR (Republic of Malawi) OR Nyasaland) OR ((Mali OR (Republic of Mali)) OR Mauritania OR ((Mauritius OR (Agalega Islands)) OR (Morocco OR Ifni) OR ((Mozambique OR (Republic of Mozambique) OR Mosambique OR Mocambique OR Moçambique OR (Portuguese East Africa)) OR ((Namibia OR (Southwest Africa) OR (Republic of Namibia) OR (South West Africa)) OR ((Niger OR (Republic of Niger)) OR ((Nigeria OR (Federal Republic of Nigeria)) OR ((Rwanda OR (Republic of Rwanda)) OR (Sao Tome and Principe) OR ((Senegal OR (Republic of Senegal)) OR Seychelles OR ((Sierra Leone) OR (Republic of Sierra Leone)) OR Somalia OR ((South Africa) OR (Union of South Africa) OR (Republic of South Africa)) OR (South Sudan) OR ((Sudan OR (Republic of the Sudan)) OR ((Tanzania OR (United Republic of Tanzania) OR Zanzibar OR Tanganyika)) OR ((Togo OR (Togolese Republic)) OR Tunisia OR ((Uganda OR (Republic of Uganda)) OR ((Zambia OR (Northern Rhodesia) OR (Republic of Zambia)) OR ((Zimbabwe OR (Zimbabwe Rhodesia) OR (Southern Rhodesia) OR (Republic of Zimbabwe))
#2	Search: ((Prevalence OR Prevalences) OR (Seroprevalence OR Seroprevalences) OR (Seroepidemiologic OR Seroepidemiological))
#1	Search: Blood AND ((Donor OR Donors) OR (Donation OR Donations))

Dois revisores (AEQ, NC) fizeram o processo de seleção do estudo, inicialmente usando software Rayyan de forma independente e, as discrepâncias foram resolvidas pelo terceiro revisor (LA). Devido ao volume considerável de resultados, decidiu-se dividir o estudo em quatro análises separadas com base nas infeções de transmissão transfusional (vírus da hepatite B, vírus da hepatite C, VIH e sífilis). Os revisores extraíram, para cada estudo incluído, as seguintes informações: *"Author name, year of publication, date of enrolment, study design, name of the country and African region where the study was performed, the total number of participants for each study (the number of blood donors tested for Hepatitis B Surface Antigen, antibody HCV, antibody HIV and VDRL/TPHA), the total number of blood donors who tested positive for Hepa titis B Surface Antigen, HCV, HIV and Syphilis which was our sample size for each included study, sex, type of blood donors (VNRBD-Voluntary Non-Remunerated Donors, RD- Replacement or Paid Donors/FD and FD-Family Donors), and the method used for screening for Hepatitis B, Hepatitis C, HIV and Syphilis diagnostic"*. O risco de enviesamento nos estudos incluídos foi avaliado de forma independente usando o programa SeroTracker-RoB: *"A decision rule-based algorithm for reproducible risk of bias assessment of seroprevalence studies"*[115] e a discrepância foi resolvida por um terceiro revisor. Este instrumento classificou os estudos segundo o risco de viés como sendo um risco baixo, moderado ou alto de viés.

• Estudo Descritivo Observacional de Prevalência

Para a pesquisa observacional, foram utilizadas duas formas de seleção dos participantes: doadores de sangue voluntários não remunerados (VNRBD) e doadores de sangue familiares de doentes hospitalizados (FRBD). As informações da base de dados incluíram: identificação codificada do doador, idade, sexo, ano de recolha, tipo de doação e nacionalidade. Os critérios gerais de exclusão dos participantes foram: dados duvidosos, ou sem registo (ausência de registo na base de dados, relativamente à idade; género e província).

No total foram incluídos 3016 doadores, com idade compreendida entre 18 - <65 anos e peso ≥ 50kg. Os doadores de sangue foram selecionados com base em critérios pré-estabelecidos. As caraterísticas das variáveis em estudo foram:

Modificáveis:

- Idade;

-Tipo de Doação

Voluntária com 66(2,4%) doadores.

Familiar com 2668(97,6%) doadores.

Não Modificáveis

- Género;

- Ano de doação;

- Nacionalidade;

- Antigénio-HBs (AgHBs);

- Anticorpo-HBc (AcHBc);
- Anticorpo do VHC;
- Anticorpo do VIH;
- VDRL e TPHA.

Amostra

• Revisão Sistemática e Meta-Análise

Quatro mil e quatrocentos e oito (4408) artigos foram identificados através de base de dados e pesquisa efetuada, tendo sido retirados 500 artigos duplicados. O título e o resumo dos 3908 foram triados e 3605 artigos foram removidos por serem considerados irrelevantes para este estudo. As restantes 303 referências foram avaliadas quanto à elegibilidade através do exame de texto completo e, destes excluímos 121 artigos completos. Destes 121, foram excluídos 43 por serem revisões sistemáticas; 18 estudos não apresentavam dados relevantes; cinco estudos não estavam disponíveis o texto integral; 27 estudos incluíram população infetada com positividade para os marcadores serológicos; 11 estudos incluíram crianças, 14 estudos incluíram mulheres grávidas e três estudos foram realizados em cuidados pré-natais (ver figura 1- PRISMA Statment). Resultaram 182 artigos que foram incluídos nas análises qualitativa e quantitativa para estimativa dos quatro marcadores serológicos das infeções de transmissão transfusional nomeadamente hepatite B, hepatite C, vírus de imunodeficiência humana e sífilis. Apresentaram critérios de inclusão para a revisão sistemática e meta-análise 124 para a hepatite B, 123 para a hepatite C, 122 para o vírus de imunodeficiência humana e finalmente 81 estudos para a sífilis.

• Estudo Descritivo Observacional de Prevalência

Foi utilizado o método de amostragem por conveniência entre duas datas de 14 de janeiro de 2011 a 30 de junho de 2016. Já na posse dos dados, elaborou-se uma tabela em Excel para comparação com os processos clínicos referentes aos doadores de sangue naquele período. Os doadores durante este período perfizeram um total de 3016 amostras de sangue a que foram aplicados os critérios de exclusão. O número total na amostra de doadores incluídos para o estudo foi de 2734, sendo 2467 (90%) homens e 267 (10%) mulheres. Destes pelo menos um apresentou resultado positivo para cada marcador serológico. Duzentas e oitenta e duas (282) amostras de sangue não apresentaram positividade para nenhum dos quatro marcadores serológicos (hepatite B, hepatite C, vírus de imunodeficiência humana e sífilis). Nestas 282 amostras, em 264 verificou-se ausência de registos relativamente à idade, sexo e proveniência da província, em 11 amostras apenas com ausência de registo da idade, cinco amostras sem idade e província e finalmente duas amostras foram excluídas por ausência de registo apenas da província. Os doadores apresentaram idades compreendidas entre 18 e 65 anos. O processo de recolha e tratamento inicial de dados foi realizado no Gabinete de Ensino Pós-Graduação e Pesquisa da Clínica Girassol de Luanda e posteriormente as características variáveis foram analisadas e desenvolvidas pelo Serviço de Estatística do Centro de Tecnologia da

Saúde e Serviços de Investigação (CINTESIS) e do Departamento de Medicina da Comunidade, Informação e Ciências de Decisão em Saúde (MEDCIDS) da Faculdade de Medicina da Universidade do Porto (FMUP). Destes 2734, 2020 (73,9%) doadores apresentaram resultados positivos para pelo menos um dos marcadores. O ano de 2016, foi um dos anos com maiores doações perfazendo um total de 796(29,1%) doações. Em relação à base de dados final, foi realizada uma tabela (ver tabela 2 (página 212), também referenciada na Publicação 1 "tabela 1"), de acordo com as características de interesse do estudo.

Tabela-2: Características sociodemográficas dos doadores de sangue da Clínica Girassol de janeiro a de 2011 a junho de 2016. Prevalência de infeção de transmissão transfusional dos doadores (n=2734).

	N	(%)
Género		
Masculino	2467	90,0%
Feminino	267	10,0%
Idade, média (Desvio Padrão)	32(9)	
<25	590	21,6%
25-29	678	24,9%
30-34	539	19,7%
35-39	386	14,1%
>40	541	19,8%
Ano de doação		
2011	281	10,3%
2012	414	15,1%
2013	410	15,0%
2014	393	14,4%
2015	440	16,1%
2016	796	29,1%
Tipo de doação		
Voluntária	66	2,4%
Familiar	2668	97,6%
Nacionalidade		
Angolana	2671	97,7%
Não Angolana	63	2,3%
AgHBs		
Positivo	1373	50,2%
Negativo	1361	49,8%
Anticorpo do VHC		
Positivo	140	5,1%
Negativo	2588	94,9%
Duvidoso	3	--
Não testado	2	--
Indeterminado	1	--
Anticorpo do VIH		
Positivo	191	7%
Negativo	2543	93%
Sífilis		
Positivo	436	20%
Negativo	1748	80%
Duvidoso	4	--
Sem registo	546	--
Doação com pelo menos uma ITT		
Não	714	26,1%
Sim	2020	73,9%
Monoinfeção	**1901**	**94,1%**
AgHBs	1286	67,6%
VIH	143	7,5%
VHC	105	5,5%
Sífilis	367	25,7%
Coinfeção	**118**	**5,8%**
AgHBs/sífilis	40	33,9%
AgHBs/VHC	22	18,6%
AgHBs/VIH	24	20,3%
VHC/VIH	4	3,4%
VHC/sífilis	8	6,8%
VIH/sífilis	20	16,9%
Tripla infeção	**1**	**0,1%**

Antigénio de superfície do vírus da hepatite B (AgHBs); vírus da hepatite C (VHC); vírus de imunodeficiência humana (VIH). As linhas a tracejado correspondem as doações remanescentes.

Análise de Dados

• Revisão sistemática e meta-análise

Todos os dados foram analisados através do software R® utilizando *metapackage*. Utilizamos como medida de efeito, a proporção de doadores de sangue que o resultado foi positivo para o antígeno de superfície do vírus da hepatite B, anticorpo do VHC, anticorpo do VIH e Sífilis. Utilizou-se o modelo de efeito aleatório de DerSimonian-Laird para estimar a seroprevalência agrupada dos 4 marcadores serológicos entre doadores de sangue em África e, os resultados foram apresentados com intervalos de confiança de 95%. Executamos o teste Cochrane Q e I^2 para avaliar a heterogeneidade e magnitude[116]. Foi realizada uma análise de subgrupo e sensibilidade para investigar o motivo da heterogeneidade. Os estudos de análise de subgrupos foram estratificados por país, região africana e ano de publicação. Para determinar os moderadores da heterogeneidade, realizamos uma análise de meta-regressão utilizando as seguintes variáveis: *"year of study publication, African region (Western, Northern, Eastern, Central, and Southern)"*. O viés de publicação foi avaliado por meio de um gráfico Funnel plot e teste de regressão estatística de Egger's. Mapeamos o padrão espacial da seroprevalência do antígeno de superfície do vírus da hepatite B, hepatite C, VIH e Sífilis entre doadores de sangue em África e por país. O mapa foi criado usando software *Quantum Geographic Information System* (QGIS)[117]. Adicionalmente, realizamos Bubble e Forest plot para os marcadores serológicos nos países africanos para identificação e distribuição específica dos marcadores nos diferentes países africanos divididos em 5 regiões, Norte, Sul, Este, Oeste e Centro de África. Especificamente, esses achados mostraram que a distribuição dos marcadores serológicos apresenta uma variação, isto é, heterogeneidade nos diferentes países africanos. Observou-se elevadas taxas de seroprevalência nas regiões do Este, Oeste e Centro de África. O Sul e Norte de África apresentaram baixas prevalências, e Angola nesta revisão teve uma baixa representação.

• Estudo Descritivo Observacional de Prevalência

As variáveis categóricas são descritas usando frequências absolutas e relativas, e as variáveis contínuas são descritas pela média e desvio padrão ou por medianas e percentis em função da simetria da sua distribuição. Os dados foram transferidos do Excel, e a análise foi realizada utilizando o programa de análise estatística SPSS®v.24.0-25 *(Statistical Package for the Social Sciences)*. A prevalência de infeções de transmissão transfusional foi expressa em percentagens por ano. O teste Qui-quadrado (χ^2) foi utilizado para avaliar a relação entre variáveis categóricas e foi aplicado para examinar a variação ano a ano, para estudar a associação entre variáveis, caracterização da amostra e a variável COM infeção versus SEM infeção. Foram construídas tabelas através do cruzamento de dados no programa de análise estatística SPSS, verificando se há presença ou não das associações entre elas estimando-se a Razão de Prevalência, com Intervalo de Confiança [IC] de 95%. Foi determinada a prevalência da coinfeção entre a população de doadores de sangue, de acordo com o grupo etário, com os subgrupos SEM infeção; Monoinfeção; Coinfeção e Tripla-infeção. De igual modo, verificou-se a coexistência em doadores com infeção entre variáveis, caracterização da amostra e as variáveis Monoinfeção versus coinfeção.

O teste de qui-quadrado de Pearson (Pearson Chi-square test) foi utilizado para avaliar a distribuição das diferenças estatísticas em cada grupo. O nível de significância de α = 5% foi considerado em todos os testes de hipóteses e o respetivo intervalo de confiança [IC] de 95% foi utilizado para estimar a magnitude da associação entre as variáveis, evidenciando a presença de significância estatística.

As referências bibliográficas foram inseridas utilizando o software EndNote.

4

RESULTADOS E DISCUSSÃO

4. RESULTADOS E DISCUSSÃO

• Estudo Descritivo Observacional de Prevalência

Dos 3016 doadores de sangue com idades compreendidas entre os 18 e 64 anos de idade que recorreram a Clínica Girassol em Luanda, 2734 com resultado positivo para cada marcador serológico foram incluídos. Foram excluídos 282 por terem resultado negativo. A média das idades foi de 32±9 anos de idade. O estudo decorreu no período compreendido entre 14 de janeiro de 2011 a 30 de junho de 2016, para rastreio do antigénio de superfície do vírus da hepatite B, anticorpo do vírus da hepatite C, anticorpo do vírus de imunodeficiência humana e sífilis. Todos os casos de marcadores positivos, foram obtidas da base de dados do Banco de Sangue e Serviço de Imunohemoterapia da Clínica Girassol, agregados por tipo de marcador. Um total de 2734 doadores apresentaram positividade para pelo menos um marcador serológico, com 1373 (50,2%) para AgHBs; 140 (5,1%) para anticorpo do VHC; 191 (7%) para o anticorpo do VIH e 436 (20%) para Sífilis.

O perfil dos doadores caracterizou-se pela predominância do género masculino com 90% em todos os marcadores serológicos. Estes doadores do género masculino, tinham uma frequência mais alta de infecções do que os doadores femininos, sendo predominante a infecção pelo VHB e VHC no género masculino e, VIH e Sífilis no género feminino, mas não foi estatisticamente significativo. Os nossos achados foram consistentes com estudos realizados em outras regiões de África como Nigéria, Malawi, República Democrática do Congo, Camarões e Etiópia[123], [124], [125], [126], [127], onde a predominância é o género masculino. Essa predominância masculina, pode ser explicada
pelos valores socioculturais do continente africano que torna o homem o candidato "mais ideal" para a doação de sangue. Na mulher, os fatores fisiológico-obstétricos como: ciclo menstrual, gravidez e a amamentação, reforçando a predominância masculina desencoraja muitas mulheres a doar sangue.

Todos os participantes eram voluntários e maioritariamente doadores de familiares. A alta prevalência observada em doadores de sangue familiares com 97,6%, também observada em estudos realizados na população egípcia onde se demostrou uma prevalência de 87,7 %[128]; para o Leste da Etiópia com 98%[127]; Índia com 85,2%[129] e Tailândia com 71%[128] doadores de sangue familiares em comparação com doadores de sangue voluntários não remunerados. Nossos resultados vão de encontro aos dados nacionais de Angola, que referem de que, 80% das transfusões de sangue são doadas por familiares[36]. Mas, ainda são escassos os estudos em que a população doadora de sangue é familiar, a maioria dos estudos encontrados de outros países, refere-se a doadores de sangue voluntários. Os nossos resultados vão de encontro aos estudos realizado na China[119]; e um

outro estudo realizado em África subsaariana, mostra que um dos principais motivos para a doação de sangue é de cariz familiar[120]. Já o estudo realizado pela União Europeia (Alemanha, Espanha, França, Grã-Bretanha, Grécia, Itália, Países Baixos, Suécia, Suíça e a Turquia países que contribuíram para o estudo), evidenciou que homens que fazem sexo com outros homens, contribuem para a doação voluntária e correspondem cerca de 0,7 a 2,5% do total de doadores[121].

Foi notável que à medida que os anos foram passando evidenciou-se um aumento dos doadores de sangue sendo no ano 2016 em que se verificou uma maior doação de sangue (ver tabela 1 da Publicação 1). Deve-se a uma maior sensibilização para a doação de sangue principalmente pelos familiares e terem havido mais internamentos de familiares que recorreram à instituição (Clínica Girassol) com necessidade de transfusão de sangue.

Descobrimos que os resultados deste estudo não estão muito distantes da realidade encontrada nos países africanos vizinhos e também da realidade espanhola encontrada na população imigrante oriunda da África subsaariana, como descrito anteriormente, no capítulo da epidemiologia.

No global (2020) 73,9%, doadores apresentaram positividade para pelo menos uma infecção no rastreio para um dos quatro marcadores serológicos e a mais alta seroprevalência foi observada para o marcador do vírus da hepatite B, Sífilis.

Os nossos achados não foram consistentes com estudos realizados anteriormente em Angola, pelos autores Guimarães et al e Peliganga et al[27,28], que demostraram uma seroprevalência baixa. Os resultados encontrados neste estudo refletem uma ideia geral da alta prevalência dos quatro marcadores de infeção de transmissão transfusional em doadores de sangue da Clínica Girassol, só podem ser interpretados dentro destes limites.

Relativamente a seroprevalência do AgHBs (marcador positivo para o vírus da hepatite B) foi de 1373(50,2%) e anti-VHC de 140(5,1%). Estudos anteriores realizados em Angola para determinar a prevalência do vírus da Hepatite B (HBV) entre doadores de sangue, não demonstraram uma alta prevalência do VHB (9,3%) na população geral e 8,5% entre os doadores de sangue[27,28], como a que encontramos neste estudo. Quando comparado com outros países africanos como Nigéria com 26,6%[130], Mali com 13,9%[131], Benin com 46,83%[132] e Tunísia com 20%[135]; Angola demostrou uma seroprevalência elevada do AgHBs.

Para o anticorpo do vírus da hepatite C encontramos uma seroprevalência de 140 (5,1%). Estudos realizados no Gabão com 6,2%[133], Nigéria com 6,0%[123], [134], Tanzânia com 8%[135] e sul da Etiópia com 8,5%[136], quando comparado com este estudo realizado na Clínica Girassol, demostraram também prevalências altas. Outros estudos realizados em outras regiões de África nomeadamente a República Centro-Africana, Burkina Faso e Sudão da Etiópia demostraram uma baixa seroprevalência de VHC, com 4,72%[137], 4,40%[138] e 4,2%[136]. De referir que países africanos como Marrocos[139] com 1,51%, Etiópia[140] com 1,6% e Namíbia[141] com 0,1%, revelaram uma seroprevalência baixa.

Essas tendências de prevalência de hepatite B, hepatite C sugerem que é crucial ser rigoroso na implementação de medidas de segurança. A elevada seroprevalência encontrada nos doadores de sangue da Clínica Girassol pode ser verificada pelos estudos que seguidamente se apresentam. A publicação 6 refere-se à incidência da hepatite B e C em doadores voluntários nesta Clínica Privada em Angola entre 2011 e 2016.

Relativamente ao anticorpo do VIH, a constatação observada nos resultados deste estudo a prevalência total foi de 191(7%). Esta é consideravelmente mais alta que a apresentada em outros estudos realizados em outras regiões da África, a título de exemplo no Sul da Etiópia[136] com 6,4%; no Egipto[128] com 0,01% e na Nigéria[142] com 4,2%. Quando comparado com Guiné Equatorial[143] com 7,83%; Moçambique[144] com 8,5%; Namíbia[145] com 9,1%; África do Sul[146] com 9,8%; Zâmbia[149] com 15,9%; Botswana com 22,9%[145] e Swazilândia[145] com 26,1%, nossos resultados revelaram uma seroprevalência baixa. A maior prevalência da infecção pelo VIH entre os doadores de sangue, ocorreu na faixa etária entre os 35 a 39 anos de idade com 10,1%. Este fato pode indicar maior frequência de exposição a potenciais fatores de risco entre os homens. Em Angola foram realizados alguns estudos de prevalência que demostraram uma seroprevalência de 8,8% para o VIH na população geral e 2,1% para o VIH em doadores de sangue [27].

O estudo observacional que demostra a seroprevalência do VIH confirmada nos testes serológicos dos doadores de sangue da Clínica Girassol, pode ser constatada na publicação 7.

Quanto à Sífilis, a alta prevalência que os nossos resultados revelam, foi identificada em um total de 2184 doadores. Observou-se uma deficiência nos registros de 546 doadores de sangue relativamente aos dados das serologias para sífilis. Em quatro doadores os resultados identificados foram duvidosos.

A prevalência da sífilis na população estudada foi de 436(20%) e encontra-se acima das prevalências identificadas por outros autores de países africanos como Camarões[126] com 8,1%; Ghana[150] com 7,5% e Tanzânia[151] com 4,7%. Quando comparada com um estudo realizado na Zâmbia[152], onde a prevalência encontrada foi de 40,5%, muito superior a demostrada no nosso estudo.

Surpreendentemente, a sífilis foi predominante em mulheres com 24,5% tem uma alta taxa de incidência o que corrobora com um estudo realizado na Namíbia sobre a sífilis que demostrou ter sido também mais prevalente em mulheres.

Os nossos achados são consistentes com estudos anteriores realizados em Guiné Equatorial[143] que apresentaram maior prevalência do *Treponema pallidum* de 21,51%. Estes resultados podem ser verificados na publicação 8.

Neste estudo foram evidenciadas variáveis associadas à infecção pelo VHB, VHC, VIH e sífilis. O estudo demonstrou uma prevalência de coinfeção de 118 (5,9%) em doadores de sangue e em 1 (0,1%) foi identificada a tripla infeção. A coinfeção predominante foi observada nos marcadores com positividade para o antígeno de superfície do vírus da hepatite B (AgHBs+) e sífilis com 40 (33,9%); AgHBs+ e VIH+ com 24 (20,3%) como mostra a tabela. Os nossos achados não foram

consistentes com estudos realizados previamente por autores angolanos[27], que demostraram uma percentagem baixa para a coinfeção da sífilis e restantes vírus nomeadamente 2,3% para VHB/VIH; 0,9% para VIH/VHC e VHB/VHC respetivamente. Nas restantes coinfeções nossos resultados demostraram igualmente uma seroprevalência alta como se pode observarn na tabela abaixo.

Tabela 3: Caraterísticas Sociodemográficas da Coinfeção dos doadores de sangue da Clínica Girassol de junho de 2011 a julho de 2016 (n=118-5,8%)

Coinfeção	N=118	%
AgHBs/Sífilis	40	33,9 %
AgHBs/VHC	22	18,6 %
AgHBs/VIH	24	20,3 %
VHC/VIH	4	3,4 %
VHC/Sífilis	8	6,8%
VIH/ Sífilis	20	16,9%
Tripla Infeção	**1**	**0,1%**

Antigénio de superfície do vírus da hepatite B (AgHBs), vírus da hepatite C (VHC), vírus de imunodeficiência humana (VIH).

A faixa etária de 35 a 39 anos representada por 17 doadores (10,1%), e doadores acima de 40 anos foram 29 (5,4%) (ver tabela 5 do manuscrito da publicação 1) apresentavam um seroprevalência mais alta quando comparado com outras faixas etárias.

A alta coinfeção que encontramos pode sugerir que, em Angola, existem fatores de risco que são relevantes para ambas as doenças. Os resultados da pesquisa enfatizam a necessidade de uma abordagem mais específica para o contexto ao lidar com a coinfeção em Angola; destacando-se a importância de levar em conta medidas preventivas na população em geral, com particular atenção nos doadores de sangue para combater eficazmente ambas as doenças.

Na generalidade, este estudo reflete uma ideia geral acerca da prevalência dos quatro marcadores de infeção de transmissão transfusional em doadores de sangue da Clínica Girassol. Neste estudo descritivo observacional, a prevalência observada foi alta e estudos realizados e publicados anteriormente em Angola não demonstraram uma seroprevalência tão elevada.

Os anos passaram e em 2016 verificou-se uma maior doação de sangue. Isso justifica-se por existirem mais internamentos na Clínica Girassol com necessidade de transfusão de sangue e ter havido uma maior sensibilização para a doação de sangue de familiares.

Por último, de referir que a ausência de registos dos indivíduos doadores de sangue, acaba por ser um fator confundidor. Este estudo demostrou a necessidade de melhorar o sistema de registos de doadores, ter conhecimento do que é feito, por quem e quando é feito, pois só mudamos aquilo que conhecemos.

Foram considerados no nosso estudo observacional, o viés de observador, viés de registos e arquivos (foram encontrados alguns registos entre as fontes de informação). Outro viés a considerar é o viés de memória porque para medir a exposição foi necessário a realização de entrevistas a doadores de sangue e estes estão sujeitos ao viéis de memória que como sabemos se desvanece com o tempo e ao fato da escassez de registos e arquivos em Angola.

Os 3 artigos que se seguem, descrevem acerca da prevalência dos marcadores separadamente HBV+HCV, HIV e Sífilis.

- Revisão sistemática e meta-análise

Relativamente aos resultados das revisões sistemáticas e meta-análises, revelaram uma considerável disparidade nos marcadores serológicos em doadores consoante a região de África. Os resultados conflituantes devem-se a diversas razões, em parte por serem de diferentes regiões, com escassez de meios, falta de estudos epidemiológicos para avaliação da seropositividade de marcadores, falta de material necessário para analisar o sangue, dado a escassez de meios notável ainda em determinadas regiões do continente africano.

Nestes estudos ficou demonstrado que a seroprevalência de AgHBs entre doadores de sangue foi de 6,93% (95% CI: 5,95 a 7,97%); VHC de 2,46% (95% CI: 1,97 a 3,00%); VIH de 2,66% (95% CI: 2,17 a 3,20%) e sífilis foi de 2,47% (95% CI: 1,81 a 3,24%), em doadores de sangue nas 5 regiões de África. Na generalidade, estes resultados quando comparados com os outros continentes, são altos. Uma revisão sistemática realizada na Europa demonstrou prevalências baixas de 0,54% para a hepatite C (95% CI:0,2 a 0,9%) e para a hepatite B (AgHBs) foi de 1,45% (95% CI: 0,9 a 2,0%[118].

Relativamente à hepatite B apenas 30 (55,5%) dos 54 países africanos foram representados nos 124 estudos incluídos. A maioria dos estudos foi realizada na África Ocidental 51 (41,1%), seguida pela África Oriental 32 (25,8%), depois pela África Central 26 (20,9%) e, por último, pela região do Norte 9 (7,3%) e Sul 6 (4,8%) de África.

Quanto ao vírus da hepatite C, 32 (59,2%) dos 54 países africanos foram representados nos 123 estudos incluídos. A maioria dos estudos foi realizada na África Ocidental 53 (43,1%), seguida pela África Oriental 29 (23,6%), depois pela Central 23 (18,7%) e, por último, pela região do Norte 11 (8,9%) e Sul 7 (5,7%) estudos de África.

Trinta (55,5%) dos 54 países africanos estão representados pelo VIH com 122 estudos incluídos. A maioria dos estudos foi realizada na África Ocidental 41 (33,6%), seguida pela África Oriental 40 (32,8%), depois pela África Central 28 (22,9%) e, por último, pela região Sul 7 (5,7%) e 6 (4,9%) do Norte de África.

Finalmente quanto à Sífilis, a maioria dos estudos foram conduzidos na África Oriental com 29 (35,8%), seguido de 27 (33,3%) de África Ocidental, 18 (22,2%) na África Central e por último 5 (6,2%) e 2 (2,5%) no Norte e Sul de África, dos 81 estudos incluídos.

O ano de publicação do estudo variou de 1990 a 2024. A maioria foi publicada depois de 2010, sendo transversal para todos os marcadores, isto pode ser explicado pelo aumento de publicações observado depois de 2010. Observou-se uma descida da prevalência dos 4 marcadores serológicos (VHB, VHC, VIH e sífilis) à medida que os anos de publicação dos estudos aumentavam, o que significa que estudos publicados recentemente depois de 2010 apresentaram menor seroprevalência do que estudos publicados antes de 2010. Isso pode ser explicado pela universalidade da vacinação no caso da hepatite B, no VIH pela expansão da terapêutica antirretroviral de alta eficácia (HAART- Highly Active Antiretroviral Therapy), na sífilis pelo tratamento com penicilina e na VHC apesar da inexistência da vacina o uso de antivirais.

Estes resultados podem ser explicados pelas diferenças existentes no acesso e qualidade dos procedimentos de rastreio, no perfil social e demográfico de cada país, no estilo de vida, na prevalência da hepatite B na população em geral e, muito mais importante, na disponibilidade de serviços de vacinação e tratamento nestes países[77, 89]. Um viés a considerar é o de publicação.

05

CONCLUSÕES

5. CONCLUSÕES

É importante considerar que a heterogenia da população de doadores estudados pode ser explicada pela variedade de resultados dos estudos publicados. Estudos epidemiológicos e clínicos de marcadores devem incluir um número de doadores suficientes para a estratificação da população que não foi o caso do nosso estudo. As doações de sangue têm várias vantagens sendo a mais importante diagnosticar e tratar precocemente reduzindo assim o risco de infeção de doenças de transmissão transfusional. O rastreio para doenças infeciosas no caso concreto de marcadores para o vírus da hepatite B, vírus da hepatite C, VIH e sífilis, possibilita o diagnóstico precoce e o encaminhamento subsequente dos indivíduos para centros especializados.

Ficou demonstrada a alta prevalência dos marcadores serológicos dos doadores de sangue da Clínica Girassol em Luanda-Angola, principalmente do vírus da hepatite B, sífilis e coinfeção.

O aumento surpreendentemente significativo do $AgHBs^{+}$ em doadores voluntários aparentemente saudáveis que recorrem à clínica para triagem obrigatória, pode ser explicado pelo aumento da prevalência da hepatite B na população geral.
Portanto conclui-se que:

- A infeção pelo vírus da hepatite B nos doadores de sangue, constitui uma causa primeira de preocupação e foi abrangente a todos os grupos etários, embora com predomínio nas idades jovens com menos de 35 anos e nos indivíduos do género masculino.
- A distribuição dos doadores por género, variou com predominância no género feminino da infeção pelo VIH e sífilis e no masculino pelo VHB e VHC.
- Estamos longe de interromper a propagação do vírus da hepatite B; embora a vacinação esteja disponível, ainda temos uma alta taxa de infeção e precisamos intensificar as medidas profiláticas.
- O rastreio da infeção pelo vírus da hepatite C, demonstrou a importância da triagem para garantir a segurança do sangue doado e evitar a transmissão de infeções por transfusão de sangue, permitindo assim o tratamento da pessoa infetada, uma vez que não existe vacinação.
- O rastreio da infeção pelo VIH nos doadores que recorreram a Clínica Girassol durante este período, revelou uma seroprevalência importante de 7%, surpreendentemente para o género feminino. Significa que o impacto sobre as doadoras é alto e isso sugere que a triagem deve ser intensificada, principalmente em gestantes de forma a evitar a transmissão materna associada ao VIH, promovendo a adoção de práticas seguras.

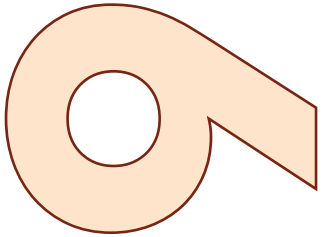
- A seroprevalência de 20% para a sífilis, significa que o impacto da doença nos doadores é alto, isso sugere que a triagem deve ser reforçada e, é urgente aumentar as campanhas de consciencilização, prevenção e controlo da sífilis, incentivando o uso de preservativos entre grupos populacionais chave, classes mais vulneráveis e definir estratégias para melhorar a abordagem para a educação de saúde.
- Determinar uma via fácil para cativar indivíduos que recorrem a Clínica Girassol para doação de sangue através de incentivos tais como realização de exames complementares de diagnóstico gratuitos.
- Cativar, sensibilizar para a importância do rastreio nos indivíduos doadores e consequentemente na restante população.
- Nas publicações citadas nesta tese, observamos cada vez mais um aumento dos marcadores positivos em doadores familiares que recorreram a instituição para doar sangue pensando serem saudáveis, e não o eram.
- Melhorar o recrutamento adequado dos doadores de sangue é uma meta a seguir, para garantir quantidade e qualidade dos componentes necessários para doação, de forma a atingir os objetivos preconizados pela OMS que são, estabelecer serviços de transfusão de sangue seguros.

Em Angola são necessárias medidas adequadas e eficientes em termos de saúde pública, com bons programas de vigilância epidemiológica, acesso a triagem, estratégias de prevenção e tratamentos bem-sucedidos para deter a disseminação dessas infeções.

Importante será alargar a triagem de doadores de sangue, tornando-a mais universal, a vacinação contra hepatite B e reforço no uso de medidas de prevenção destas patologias. A elevada prevalência de hepatite viral, especialmente a infeção pelo vírus da hepatite B, representa uma mudança significativa no perfil dos doentes tratados em Angola e exige medidas destinadas ao diagnóstico precoce e prevenção de transmissão. As infeções causadas por estes agentes são um problema importante a considerar.

Para evitar rutura de *stock*, é essencial incentivar mais doações de doadores voluntários para atividades de doação de sangue e simultaneamente em rastreio prévio e precoce de forma a debelar estas infeções transfusionais.

Infelizmente não existe vacina para prevenção da infeção pelo vírus da hepatite C, pelo que fica claro que são necessárias práticas de intervenções para diminuir o risco de transmissão do VHC bem como do VHB, incluindo a adesão estrita às precauções padrão no ajuste dos cuidados médicos, a instrução rigorosa e a formação de doadores, bem como de doentes e dos cuidados médicos prestadores de serviços.



LIMITAÇÕES E CONSIDERAÇÕES FINAIS

6. LIMITAÇÕES E CONSIDERAÇÕES FINAIS

• Estudo observacional

Como é sabido, a natureza transversal dos desenhos de estudos observacionais retrospetivos, não permite extrair inferências causais dos achados demonstrados. Estes resultados também não podem ser generalizados, uma vez que se centrou principalmente em doações realizadas na Clínica Girassol. Seria crucial que o estudo abrangesse outras instituições, analisando as caraterísticas do doador durante vários anos e por um período mais longo. No entanto, a categorização dos dados com base neste estudo deu alguma indicação das infeções de transmissão transfusional.

É importante destacar que os indivíduos que procuram a Clínica, na sua maioria, possuem melhores recursos, pelo que consideramos uma limitação do estudo o fato de ter sido realizado apenas em uma clínica privada, onde nem todos os indivíduos têm acesso.

• Revisão sistemática e meta-análise

Esta revisão sistemática e meta-análise teve algumas limitações, nomeadamente, a seroprevalência agrupada de AgHBs/VHB, VHC, VIH e sífilis entre doadores de sangue que encontramos não têm validade externa para o continente africano, pois 25 (46%) para VHB e VIH, 24 (44%) para VHC e finalmente 32 (59%) para sífilis, dos países africanos não foi encontrado nenhum estudo sobre o tema. Evidenciou-se uma sobrerrepresentação dos estudos em países localizados nas regiões do Ocidente, Centro e Oriente de África e sub-representação nos países das regiões Norte e Sul do continente africano. Além disso, encontramos maior heterogeneidade entre os estudos incluídos (I^2= 99,9% para VHB; 99,8% para VHC, VIH e sífilis).

Considerações finais

Todas as infeções referidas anteriormente e vias de contaminação, são perfeitamente conhecidas, sendo possível prevenir a contaminação. O rastreio das infeções deverá ser realizado sempre não só no doente como para os contatos com risco de exposição. Há também interesse de Saúde Pública e por razões de vigilância epidemiológica, compreende-se a obrigatoriedade da sua realização em doadores de sangue, tecidos e órgãos.

Atendendo à alta prevalência verificada, a melhor atitude para a prevenção deve orientar-se principalmente para a modificação de comportamentos, estratégia extremamente fundamental. É tarefa prioritária de todo o profissional de saúde a promoção da modificação de comportamentos humano através da educação, da informação repetida, adequada e apropriada a cada indivíduo.

A vigilância, controle e prevenção requerem monitorização contínua da transmissão do VHB, VHC, VIH e sífilis. Portanto, é imperativo melhorar a triagem dos critérios de seleção de doadores e o uso de uma combinação de métodos de seleção de doadores que forneçam sangue seguro em Angola contribuindo assim para a redução da prevalência. Isto requer o envolvimento e contributo da sociedade civil.

O rastreio rigoroso de todos os produtos sanguíneos, órgãos e tecidos, e a adesão às medidas de controlo das infeções e às precauções universais são regras essenciais e absolutamente necessárias, que devem ser implementadas para que a doação de sangue seja segura não só em Angola, como no mundo.

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ANEXOS

8. ANEXOS

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Anexo 1. Declaração da Comissão de Ética de Angola

REPÚBLICA DE ANGOLA
MINISTÉRIO DA SAÚDE

COMITÉ DE ÉTICA

Nº 04 2018

DECLARAÇÃO

JOANA FILIPA MACHADO DE MORAIS AFONSO, Presidente do Comité de Ética declaro que, **Dra. Angelina Edna Edmunda Columbana Bia Quintas**, submeteu a este comité o projecto de pesquisa intitulado «Prevalências de marcadores da Hepatite B, Hepatite C, HIV e Sífilis em Doadores de Sangue em Angola Atendidos na Clínica Girassol Durante o Período de 2011 a 2016».

Por ser verdade e me ter sido solicitada a presente declaração, está «**AUTORIZADA**» a publicar os dados da pesquisa.

LUANDA, AOS 16 DE FEVEREIRO DE 2018.

A PRESIDENTE DO C.E
DRA. JOANA FILIPA M. M. AFONSO

REPÚBLICA DE ANGOLA
MINISTÉRIO DA SAÚDE

COMITÉ DE ÉTICA

Nº 25 2017

Sobre o projecto de pesquisa intitulado «**Prevalência de marcadores da Hepatite B, Hepatite C, HIV e Sífilis em doadores de sangue em Angola, atendidos na Clínica Girassol durante o período de 2011 a 2016**», submetido a este Comité pela **Dra Angelina Adna Edmunda Columbana Bia Quintas,** aluna de Doutoramento pelo Departamento de Ciências da Informação e da decisão em Saúde da Faculdade de Medicina da Universidade do Porto, cidade do Porto- Portugal.

A leitura e análise da proposta do protocolo de estudo, permitiu ao Comité de Ética constatar que o parecer é «**Positivo**» porque o estudo visa identificar a incidência e quantidade de marcadores positivos das Hepatites B, C, HIV e Sífilis nos dadores de sangue.

Contudo, deve afirmar-se que qualquer possibilidade ou vontade em publicar os dados advindos do estudo, deve ser primeiro solicitado ao Ministério da Saúde bem como ao Comité de Ética do mesmo.

LUANDA, AOS 20 DE JUNHO DE 2017

A COORDENADORA
DRA. JOANA FILIPA M. M. AFONSO
"BIOMÉDICA"

Anexo 2. Pedido de mudança de tema

PDICSS

Porto, 06 de setembro de 2023

Exmo. Senhor
Diretor da
Faculdade de Medicina da Universidade do Porto

Assunto: Pedido de mudança de tema

Eu, Angelina Edna Edmunda Columbana Bia Quintas, estudante com o número 200600081, inscrita no Programa Doutoral em Investigação Clínica e em Serviços de Saúde, venho solicitar a mudança do tema inicialmente proposto para o meu projeto de investigação.

O tema inicialmente proposto foi **"Estudo da hepatite C crónica, genótipo 4: caracterização epidemiológica e clínica"**. No entanto, por se ter revelado impossível a colheita dos dados necessários para desenvolver o projeto, nomeadamente dados da genotipagem, foi necessário reformular o projeto e efetuar nova colheita de dados.

Desde então tenho desenvolvido os meus trabalhos no âmbito do novo tema com o título provisório **"Prevalência de Marcadores da Hepatite B, Hepatite C, Vírus de Imunodeficiência Humana e Sífilis em Dadores de Sangue em Angola, atendidos na Clínica Girassol durante o período de 2011 a 2016"** mantendo a orientação do Doutor António Carlos Magro Eugénio Sarmento, Professor Catedrático Convidado da Faculdade de Medicina da Universidade do Porto e a coorientação do Doutor Altamiro Manuel Rodrigues da Costa Pereira, Professor Catedrático e Diretor da Faculdade de Medicina da Universidade do Porto e do Doutor Lemuel Bonnelli Cordeiro, Professor Associado do Gabinete de Ensino Pós-Graduação e Pesquisa da Clínica Girassol de Luanda.

Com os melhores cumprimentos,

Angelina Edna Quintas

Rua Dr. Plácido da Costa, s/n | 4200-450 | Porto | Portugal E-mail: pdicss@med.up.pt | Telefone: +351 225 513 622

Anexo 3. Declaração de Consentimento Informado do doador de sangue

Clínica Girassol	TERMO DE CONSENTIMENTO INFORMADO DADOR VOLUNTÁRIO REGULAR	Nº: FO CHBS 0085 Revisão: 001 Data: SET 2015 Página: 01 de 01
	CENTRO DE HEMOTERAPIA E BANCO DE SANGUE	

DADOS DO DADOR VOLUNTÁRIO REGULAR:

Nome Completo:

Data de Nascimento:

Nº do BI (ou passaporte):

O presente Termo de Consentimento Informado tem o objectivo de cumprir o dever ético de informar ao potencial candidato a doação de sangue voluntária regular quanto aos principais aspectos relacionados com as etapas da doação de sangue a que será submetido no Centro de Hemoterapia e Banco de Sangue da Clínica Girassol.

Este espaço, a seguir, deverá ser preenchido pelo paciente e/ou responsável.

Eu, _____

Portador do BI Nº: _____

☐ Declaro estar ciente que o processo de doação compreende: entrevista clínica, colheita de uma bolsa de sangue e de amostras de sangue para realização de exames laboratoriais para doenças infecciosas transmissíveis por transfusão.

☐ Autorizo a repetição dos testes laboratoriais e a realização de exames confirmatórios se houver algum resultado reagente ou inconclusivo associado à dação.

☐ Estou ciente que qualquer resultado alterado será informado apenas a mim, o potencial dador, não sendo permitida a entrega a meus responsáveis legais nem a terceiros sem a minha expressa autorização.

☐ Autorizo, desde que o meu nome seja incorporado ao arquivo de dadores voluntários regulares do Centro de Hemoterapia da Clínica Girassol e caso o sangue doado não seja utilizado para transfusão nesta instituição, autorizo o seu envio para utilização em outros centros.

☐ Declaro estar ciente que a rotina e os critérios de selecção para que eu receba o estatuto de dador regular obedecem os dispostos do Regulamento para Doação de Sangue da Clínica Girassol, cujo conteúdo tomei conhecimento e recebi uma cópia por ocasião do meu cadastro.

_____

Assinatura legível

Data: _____ Hora: _____

Este espaço, a seguir, deverá ser preenchido pelo médico.

Expliquei o processo doação de sangue ao potencial dador acima identificado. Expliquei ainda sobre os benefícios, riscos, alternativas, tendo respondido às perguntas formuladas pelos mesmos. De acordo com o meu entendimento, candidato poderá ser enquadrado dentro do estatuto de dador regular desde que cumpra as condições estabelecidas no regulamento interno.

_____

Assinatura legível do Médico

Data: _____ Hora: _____ Nº da Ordem: _____

FO CHBS 0085 – Versão 001

Anexo 4. Triagem clínico-epidemiológica do doador de sangue

Clínica Girassol	TRIAGEM CLÍNICA	Nº: FO CHBS 0007 Revisão: 001 Data: SET 2015 Página: 01 de 02
	CENTRO DE HEMOTERAPIA E BANCO DE SANGUE	

Nome Completo: **Data da Triagem:**

Data de Nascimento: **Idade:** **Sexo:** ☐FEM ☐ MASC

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO:

☐ Declaro que as informações por mim prestadas são verdadeiras e desde que estejam dentro dos critérios para doação de sangue, consinto que sejam retirados 450mL do meu sangue para uso deste serviço. Autorizo ainda, a realização de exames serológicos exigidos por lei.

Assinatura do doador

PESO	ALTURA	TEMP.	FC	PA	HT/HB	T. RÁPIDO MALÁRIA	ABO/Rh(D)

RESPONSÁVEL	GE	RESPONSÁVEL

1.	Já doou sangue?	NÃO	SIM	Há Quanto Tempo? Quantas Vezes?				
2.	Teve algum problema em doações anteriores?	NÃO	SIM	Qual?				
3.	Apresentou algum dos exames de sangue alterados?	NÃO	SIM	Qual				
4.	Tem o hábito de ingerir bebida alcoólica?	NÃO	SIM	Bebeu hoje?	NÃO	SIM	☐> 6h	☐<6hs
5.	Tem o hábito de fumar?	NÃO	SIM	Fumou hoje?	NÃO	SIM	☐> 2h	☐<2hs
6.	Faz uso de alguma medicação?	NÃO	SIM	Usou nos últimos 15 dias?			NÃO	SIM
				Qual?				
7.	Fez tatuagem, piercing ou acupuntura?	NÃO	SIM	Há quanto tempo?				
8.	Tomou vacina no último ano?	NÃO	SIM	Qual Vacina? Quando?				
9.	Teve alguma doença grave ou ficou internado?	NÃO	SIM	Qual doença? Quando?				
10.	Fez alguma cirurgia no último ano?	NÃO	SIM	Qual? Quando?				
11.	Está realizando algum tratamento dentário?	NÃO	SIM	Quando:				
12.	Teve malária/paludismo?	NÃO	SIM	Quando:				
13.	Teve Ameblase (fezes com muco, sangue, diarreias)?	NÃO	SIM	Quando:				
14.	Já teve doença de Chagas e/ou Tripanossomíase Africana (doença do sono)?	NÃO	SIM	Quando:				
15.	Teve sífilis, gonorreia, herpes ou outra DTS?	NÃO	SIM	Quando terminou o tratamento?				
16.	Já recebeu transfusão de sangue e/ou derivados?	NÃO	SIM	Quando:				
17.	Já se submeteu a transplante?	NÃO	SIM	Quando:				
18.	Tem asma, problemas alérgicos?	NÃO	SIM	Alergia a quais produtos?				
19.	Está alimentado	NÃO	SIM					
20.	Dormiu mais do que 6 horas nas últimas 24 horas?	NÃO	SIM					
21.	Tem problemas cardíacos (cansaço, dor torácica...), respiratórios, Diabetes Insulino-dependente, Doença Auto-imune, Hipertireoidismo, Hematológica, Doenças Renais?						NÃO	SIM
22.	Teve desmaio, convulsão, problemas neurológicos?						NÃO	SIM
23.	Teve febre, tosse persistente, suores noturnos, perda de peso importante, diarreia?						NÃO	SIM
24.	Tem ou teve Tuberculose, Brucelose, Exantema cutâneo, Herpes Zóster, Cancro?						NÃO	SIM
25.	Está grávida? Amamentando?						NÃO	SIM
26.	Teve parto ou aborto nos últimos 3 meses?						NÃO	SIM
27.	Qual seu estado civil? ☐ Solteiro ☐ Casado ☐Mora com um companheiro ☐Separado							
28.	Seu parceiro apresenta algum problema de saúde?	NÃO	SIM	Qual?				
29.	Você e/ou seu(s) parceiro(s) tiveram Hepatite e/ou Icterícia?	NÃO	SIM	Com que idade?				
30.	Já teve relação homossexual ou parceiro que tenha tido						NÃO	SIM
31.	Teve relação sexual com alguém suspeito de ser portador do vírus da SIDA / VIH?						NÃO	SIM
32.	Já utilizou drogas ou teve parceiro sexual que utilizou?						NÃO	SIM
33.	Já esteve detido em instituição carcerária?						NÃO	SIM
34.	Tem familiares com falciformação?						NÃO	SIM

Observações: **Fraccionar Plaquetas:** ☐Sim ☐Não

☐ APTO	☐ INAPTO TEMPORÁRIO	☐ INAPTO DEFINITIVAMENTE
Triagem realizada por:	**MOTIVO (INAPTO):**	

FO CHBS 0007 – Versão 001

Clínica Girassol	TRIAGEM CLÍNICA	Nº: FO CHBS 0007 Revisão: 001 Data: SET 2015 Página: 02 de 02
	CENTRO DE HEMOTERAPIA E BANCO DE SANGUE	

ACOMPANHAMENTO DA SANGRIA

Punção venosa: ☐ Braço direito ☐ Braço esquerdo

Início da sangria: Término da sangria: Duração da sangria: ☐ Sangria não realizada

Doação: Sim ☐ Não ☐ Volume colectado: Motivo: Fraccionar Plaquetas: ☐ Sim ☐ Não

Reacção: ☐ Nenhuma ☐ Leve ☐ Moderada ☐ Grave Qual:

Sangria realizada por:

REACÇÕES ADVERSAS DURANTE E/OU APÓS A SANGRIA

☐ Acesso venoso difícil	☐ Ansiedade	☐ Convulsão
☐ Contrações musculares involuntárias ou tetania	☐ Fluxo sanguíneo insuficiente	☐ Hematoma
☐ Hemorragia	☐ Hipoglicemia	☐ Hipotensão
☐ Lipotimia	☐ Náusea	☐ Palidez
☐ Parestesia	☐ Paragem cardiorrespiratória	☐ Perda de acesso venoso
☐ Punção arterial	☐ Sudorese	☐ Suspeita de AVC ou IAM
☐ Suspeita de lesão nervosa	☐ Taquicardia	☐ Tontura
☐ Vómito	☐ Outros (anotar):	

PROCEDIMENTOS

Hora	Tensão Arterial	F.C.	F.R.
Hora	Tensão Arterial	F.C.	F.R.

☐ Acesso venoso periférico	☐ Avaliação médica	☐ Aplicação de bolsa de gelo
☐ Aplicação de bolsa morna	☐ Aplicação de pomada anti-inflamatória	☐ Curativo compressivo
☐ Desobstrução de vias aéreas superiores		☐ Interrupção da colheita
☐ Posição de Trendelenburg	☐ Respiração em saco	☐ Transferência para Sala de Recuperação

☐ Medicação:

☐ Solicitação de apoio da Equipa de Urgências do Hospital Hora:

EVOLUÇÃO

Hora:

Hora:

Hora:

Assinatura do Médico da Hemoterapia	Colar neste espaço a etiqueta de colheita
Assinatura do Enfermeiro/Técnico que acompanhou o procedimento	

PUBLICAÇÃO 1

Seroprevalence of Viral Transfusion Transmissible Infections (HBsAg, anti-HCV, anti-HIV, Syphilis) and Coinfection among Healthy Volunteer Blood Donors during 5 years in Luanda, Angola.
Angelina Edna Quintas, Cláudia Camila Dias, Adis Del Carmen Cogle, Lemuel Cordeiro, António Sarmento. *The Brazilian Journal of Infectious Diseases* 2023; 27(6):103704

BRAZ J INFECT DIS. 2023;27(6):103704

The Brazilian Journal of
INFECTIOUS DISEASES

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Original Article

Seroprevalence of viral transfusion transmissible infections (HBsAg, anti-HCV, anti-HIV, Syphilis) and coinfection among healthy volunteer blood donors during 5-years in Luanda, Angola☆

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ARTICLE INFO

Article history:
Received 20 June 2023
Accepted 12 November 2023
Available online 27 November 2023

Keywords:
Transfusion-transmissible infection
Seroprevalence
Blood donors
África

ABSTRACT

Background: The transmission of diseases by blood products continues to be a worldwide health problem, especially in Africa. Seroprevalence rates of the Hepatitis B virus (HBV), Hepatitis C virus (HCV), Human Immunodeficiency Virus (HIV), Syphilis, and Coinfection in Angola are poorly documented. This study aims to identify the seroprevalence of markers with positive results for Hepatitis B, C, HIV, Syphilis, and Coinfection in blood donors.
Material and methods: A retrospective study was conducted using a database of positive serological markers for these infections and coinfection in 2734 blood donors traced from 2011 to 2016 in Luanda, Angola. The Chi-Square test ($\chi 2$) or Fisher's exact test was used to evaluate serological positivity and donors' characteristics. A p-value < 0.05 was considered statistically significant.
Results: 2734 blood donors aged 18 to 64 (median age 32 ± 9) were screened from 2011 to 2016. 73.9 % of the donors were positive for one Transfusion-Transmitted Infection (TTI), and 5.9 % showed evidence of multiple infections. The overall seroprevalence rate was 50.2 % (1373) for HBV, 20 % (436) for Syphilis, 7 % (191) for HIV, 5.1 % (140) for HCV, and 5.8 % for coinfected donors. 2467 (90 %) were men, and 267 (10 %) were women. We identified 118 (5.8 %) coinfected donors. Of those, 40 (33.9 %) simultaneously presented Hepatitis B virus surface antigen (HBsAg)/Syphilis, 24 (20.3 %) HBsAg/HIV, 22 (18.6 %) HBsAg/HCV, 20 (16.9 %) HIV/Syphilis, 8 (6.8 %) HCV/Syphilis, and 4 (3.4 %) HIV/HCV.

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https://doi.org/10.1016/j.bjid.2023.103704

Conclusion: A high transfusion-transmissible infection prevalence was found compared to some countries in Sub-Saharan Africa. Therefore, intensifying the screening for these transfusion-transmitted infections in blood donors is critical to ensure blood safety.

Introduction

In Southern Africa, safety in blood transfusion and its derivatives remains compromised by multiple and diverse factors and is affected by a high prevalence of transfusion-transmitted infections. Infections such as Hepatitis B, Hepatitis C, and HIV are of great concern because of their prolonged viremia and latent status.[1] It is believed that the risk is high in countries of Sub-Saharan Africa, which is why the World Health Organization (WHO) has implemented standards for safe blood transfusion.[2,3] Previous studies conducted in Angola to determine the prevalence of transfusion-transmitted infections, such as Hepatitis B virus (HBV), Hepatitis C virus (HCV), Human Immunodeficiency Virus (HIV), and Syphilis among blood donors, demonstrated a high prevalence of HBV, HCV, and Syphilis with 9.3 %, 8.1 %, 8.8 % and 4.6 %, respectively. For coinfection, the prevalence was 2.3 % for HIV/HBV, 0.9 % for HIV/HCV, 0.9 % for HBV/HCV, and a lower percentage for Syphilis coinfection with remaining viruses.[4]

Our study focused on determining the prevalence of transfusion-transmitted infections (HBV, HCV, HIV, and Syphilis) among blood donors in Angola while also investigating any correlation between the donors' sociodemographic characteristics, the transfusion-transmitted infections addressed in this study and the presence of coinfection.

In the present study, seroprevalence for Hepatitis B virus surface antigen (HBsAg), Hepatitis C Virus antibody (anti-HCV), Human Immunodeficiency Virus Type 1/2 antibody (anti-HIV), Syphilis, and coinfection in volunteer blood donors was performed at the Clínica Girassol, in Luanda, from January 2011 to June 2016.

Materials and methods

This retrospective study analysed the records of blood donations made by new and regular donors in Luanda from 14 January 2011 to 30 June 2016. All blood donors were healthy and non-remunerated volunteers. The study was conducted at the Girassol Clinic in Luanda (Fig. 1), which is responsible for their blood donor recruitment, collection and testing. The clinic's Immuno-hemotherapy and Blood Bank service receives donors from various regions of the country.

Clínica Girassol is a private-public health institution located in the province of Luanda, the capital of Angola, a country with 18 provinces in the southern region of Africa. Angola is bordered to the north and northeast by the Democratic Republic of Congo and Congo Brazzaville, to the east by Zambia, and the south by Namibia and Botswana. To the west, it is bathed by the Atlantic Ocean (Fig. 1). According to the United Department of Economic and Social Affairs of the United Nations, the Angolan population in 2022 corresponded to 35 588 987 inhabitants[5,6] and Luanda, the capital, with a current population of 7.3 million.[7] Many individuals from other provinces resort to the clinic for better medical care. The centre has many departments, sections, and sub-sections. It comprises a donor, laboratory, Immunohematology, and component preparation sections. The National Blood Transfusion Service reviews the programme regularly. The collection of markers is safe, and the laboratory analyses them automatedly with high specificity and sensitivity. In the blood donation process, various methods are used to raise awareness among people, individually or in groups and involving families, about the importance and necessity of donating blood to enable treatments and therapeutic procedures for those in need. An increasing number of donors with screening indications are turning to this institution to donate blood to contribute to improving blood stocks nationwide.

All blood donors were healthy and non-remunerated volunteer blood donors. All donors conducted by the transfusion-transmitted infections section to test for Hepatitis B, Hepatitis C, HIV, and Syphilis were performed. The information from the database included coded donor ID (identification), age, sex, year of collection, type of donation, and Nationality. The outcome variables were HBV, HCV, HIV, Syphilis seropositivity and overall transfusion-transmitted infections as well as co-infections.

Pearson Chi-Square test for statistical difference in the distribution with each group was used. MI (Multiple Infection) corresponds to dual or co and triple infections. Doubtful, without register and missing data were excluded. Clínica Girassol provides health services to the locals and the population coming from different zones of the region. Doubtful results are serological results which, according to the reference value, are between 0.8–0.9 and which, after repeating the test, remain at the same values, so the blood with these results is discarded.

Statistical analysis

The database was transferred from Excel, and the analysis was performed using the statistical analysis program SPSS®v.24.0 (Statistical Package for the Social Sciences). Categorical variables are described using absolute and relative frequencies, and continuous variables are described by the mean and standard deviation or by medians and percentiles as a function of the symmetry of their distribution. No sample size was calculated. It was a convenience sample between two available dates. The prevalence of transfusion-transmitted infections was expressed in percentages per year. The Chi-Square test (χ^2) was used to evaluate the relationship between categorical variants and was applied to examine

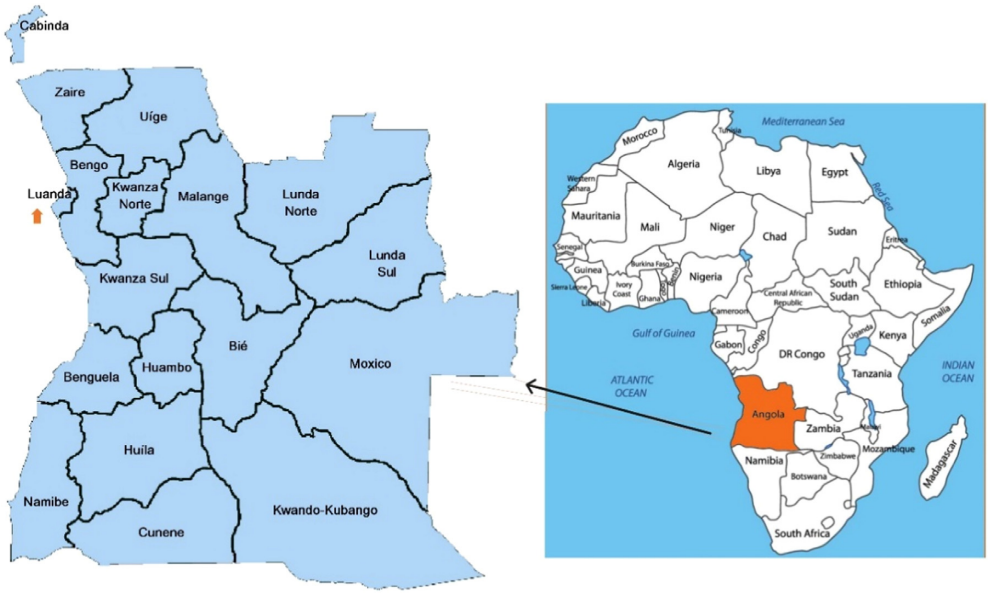

Fig. 1 – Map of Africa showing the location of Angola (on the right), the city of Luanda (arrow) and Clínica Girassol (on the left).[5]

year-by-year variation. A significance level of $\alpha = 5$ % was considered in all hypothesis tests.

This study follows the STROBE Statement. Permission to conduct this study and ethical clearance was obtained from the Research Ethics Committee of the National Institute of Public Health of the Ministry of Health of Angola (Reference 25/2017 and 04/2018). Written permission was obtained from the National Institute of Public Health of the Ministry of Health of Angola. The confidentiality of the information extracted from the participants' records was maintained by not recording any personal identifiers. The data extracted were secured and made available only to the study's principal investigator. All donors signed an informed consent form (Reference FOCHBS0065) before blood collection, and blood donors were analysed anonymously. All methods were carried out in accordance with the Declaration of Helsinki.

Results

Study population

The study included 2734 blood donors who were screened and donated blood from 14 January 2011 to 30 June 2016. All the participants were Volunteers and Non-Remunerated Blood Donors (VNRBD). Some were Family Replacement Blood Donors (FRBD), i.e., individuals who donated blood because they had a family member or friend hospitalised in the institution who needed blood (2668). Other donors were volunteers, i.e., individuals who were aware of the importance of blood donation to save lives and donate selflessly (66).

The blood donors were selected based on pre-set criteria based on age (18 – ≤ 65 years) and weight (≥ 50 kg). For clinical screening, a standard clinical history form was provided to be filled in and used for donor selection according to the institutional protocol. According to institutional eligibility criteria, for individuals to donate blood, they must not have a history of high-risk sexual behaviour or practice, must have never received a blood transfusion, must not have jaundice, fever, or hypertension and must have never had hepatitis or surgery, among other criteria.

Two thousand seven hundred thirty-four (2734) donors tested positive for the Hepatitis B virus surface antigen (HBsAg), Hepatitis B virus core antibody (Anti-HBc), Hepatitis C virus antibody (anti-HCV), Human Immunodeficiency Virus Type 1/2 antibody (anti-HIV) and Syphilis infection markers. Two hundred eighty-two (282) donors did not present seropositivity for the 4 most frequent markers previously mentioned. Venous blood and plasma were collected for screening for HBsAg, anti-HCV, anti-HIV and Syphilis (Fig. 2).

Database and blood collection

This is an institutional database with national impact, where all the data related to the internal process of each donor is recorded and stored through a code assigned to each donor, allowing this information to be analysed later. For our study, a database was created in Excel, and a structure was defined for the data where only the variables of interest to our study were entered, which refer to transfusion-transmitted infections, namely HBV, HCV, HIV and Syphilis. Concerning screening for Human T-Lymphotropic Virus (HTLV) infection, it wasn't our aim to talk about it, but it could be a topic for

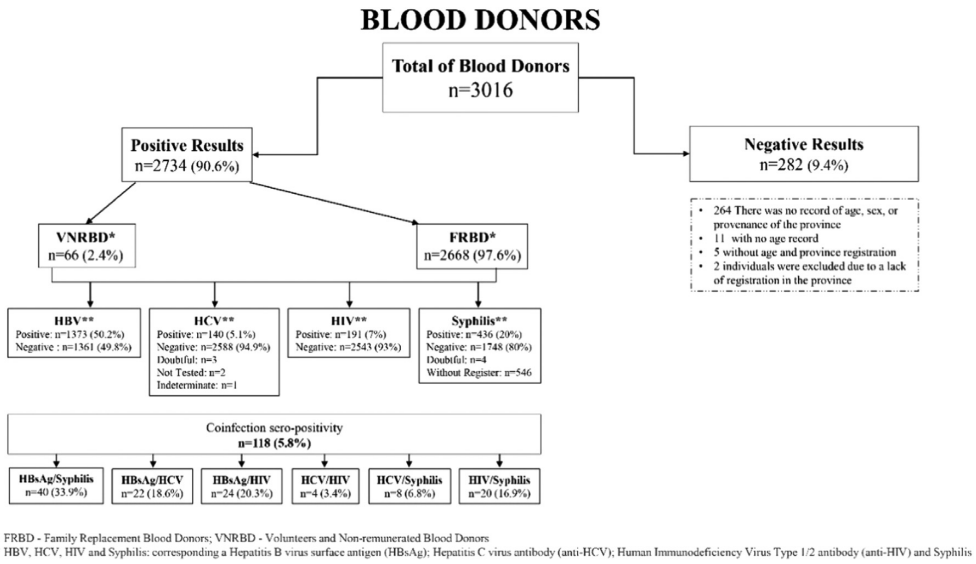

Fig. 2 – Summary of the blood donors' records reviewed and TTIs.

discussion in a future publication, as could malaria, an endemic condition in our country.

Venous blood and plasma were collected from volunteer donors (everyone, voluntary non-remunerated blood donors and family blood donors) and their relatives in tubes, which were used for screening for HBsAg, anti-HCV, anti-HIV and Syphilis, according to blood collection regulations and standards.

Serology

The Blood transfusion service of the Immuno-Hemotherapy service of Clínica Girassol meets the guidelines for mandatory blood donor screening. Enzyme-linked Immunosorbent Assay (ELISA) was used for the screening of blood of the HBV, HCV, HIV antibodies and Syphilis using the automated *Treponema pallidum* Hemagglutination Assay (TPHA) and then repeated using VDRL (Venereal Disease Research Laboratory). Three confirmatory tests were performed. Two tests were used in parallel. Then, a third confirmatory test was used for discordant results.

Screening of HBsAg, antibody HCV, antibody and HIV I/II antigen

Screening of Hepatitis B virus surface antigen (HBsAg) was performed using the Enzyme-linked immunosorbent assay (ELISA) kits ARCHITECT plus i1000Sr Abbott (ARCHITECT AgHBs Qualitative Test Kit). Test procedures and interpretation of results are done according to the instructions in the manufacturer's manual. Samples with questionable results, i. e. grey zone, are repeated, using the same Kit and other methodology, confirming the result in the Cobas and 601 Roche. Repeatedly positive samples were considered Hepatitis B virus surface antigen and Hepatitis B virus core antibody (AcHBc) positive. Regarding the Hepatitis C virus antibody (anti-HCV) and Human Immunodeficiency virus antibody (anti-HIV), the grey zone was repeated using the same Kit and other methodology, confirmed by the ADVIACentaur XP Immunoassay System.

Anti-Syphilis antibody screening

Antibody detection (IgG and IgM) for *Treponema Pallidum* (TP) was performed using the Enzyme-linked immunosorbent assay (ELISA) kits ARCHITECT plus i1000Sr Abbott. Test procedures and interpretation of results were done according to the instructions in the manufacturer's manual. The dubious grey zone results were repeated using the manual method TPHA/VDRL, the latter being considered the most specific procedure for confirming the test as a final result.

All tests used for screening have sensitivity and specificity above 99 %, according to the manufacturer, with regular quality control. The Laboratory of the Immuno-hemotherapy Service is certified by the Certified IQNet Management System.

Sociodemographic characteristics and time of donors

Two thousand seven hundred thirty-four (2734) donor samples were retrieved and analysed. The year with the most donations was 2016. The characteristics of the study population are shown in Table 1 according to the total distribution of the donors and the seroprevalence of the four transfusion-transmitted infections. Most donors were male, aged 18–64 years old, with a mean age of 32±9 years.

Seroprevalence of transfusion-transmitted infections

Among the donors, 73.9 % (95 % CI 72.2–75.5) tested positive for at least one transfusion-transmitted infection. The data

Table 1 – Sociodemographic Characteristics of blood donors of Clínica Girassol from June 2011 to June 2016. Prevalence of TTIs (*n* = 2734).

	N	(%)
Sex		
Male	2467	90.0 %
Female	267	10.0 %
Age, mean (SD)	32 (9)	
< 25	590	21.6 %
25–29	678	24.8 %
30–34	539	19.7 %
35–39	386	14.1 %
≥ 40	541	19.8 %
Year of collection (donation)		
2011	281	10.3 %
2012	414	15.1 %
2013	410	15.0 %
2014	393	14.4 %
2015	440	16.1 %
2016	796	29.1 %
Type of donation		
Voluntary (VNRBD)	66	2.4 %
Family (FBD)	2668	97.6 %
Nationality		
Angolan	2671	97.7 %
Non-Angolan	63	2.3 %
HBsAg		
Positive	1373	50.2 %
Negative	1361	49.8 %
Anti-HCV		
Positive	140	5.1 %
Negative	2588	94.9 %
Doubtful	3	—
Not Tested	2	—
Indeterminate	1	—
Anti-HIV		
Positive	191	7 %
Negative	2543	93 %
Syphilis		
Positive	436	20 %
Negative	1748	80 %
Doubtful	4	—
Without register	546	—
Infections with at least one TTI		
No	714	26.1 %
Yes	2020	73,9 %
Mono-infection	**1901**	**94.1 %**
HBsAg	1286	67.6 %
HIV	143	7.5 %
HCV	105	5.5 %
Syphilis	367	25.7 %
Coinfection (Dual Infections)	**118**	**5.8 %**
HBsAg/Syphilis	40	33.9 %
HBsAg/HCV	22	18.6 %
HBsAg/HIV	24	20.3 %
HCV/HIV	4	3.4 %
HCV/Syphilis	8	6.8 %
HIV/Syphilis	20	16.9 %
Triple Infection	**1**	**0.1 %**

Dotted lines (—) correspond to a remaining donation. The results were negative for the four TTIs tested, being doubtful, untested and undetermined in 5 donors in HCV antibody determination. Syphilis was identified as a failure in the registries. In 546 donors, there was no record of Syphilis serologies, and in 4 donors, the results were doubtful (serological results which, according to the reference value, are between 0.8–0.9 and which, after repeating the test, remain at the same values, so the blood with these results is discarded). Voluntary Non-Remunerated Blood Donors, Family Blood Donors. Hepatitis B Virus surface Antigen (HBsAg), Hepatitis C Virus antibody (anti-HCV), Human Immunodeficiency Virus Type 1/2 antibody (anti-HIV).

shows that the highest proportion of donors was most notable in the 25–29 age group, which makes up 24.8 %. Most individuals gave blood as Family Blood Donors (FBD), i.e., 97.6 %, while Voluntary Non-Remunerated Blood Donors (VNRBD) accounted for the remaining proportion, 2.4 %. Despite being low, foreigners also contributed to a small blood donation, representing about 2.3 %.

Table 2 summarises the positivity rate of transfusion-transmitted infections among donors by year. Hepatitis B was the most prevalent type throughout the 5 years. The overall prevalence of transfusion-transmitted infections fluctuated during the study period. The Chi-Square test showed a significant decrease ($p < 0.001$) over the 5 years. Tables 3 and 4 show the seropositivity of transfusion-transmitted infections within specific sociodemographic categories, including sex and age.

Male donors had a higher frequency of transfusion-transmitted infections than female donors, but this was not statistically significant. Female donors had a significantly higher frequency of HIV ($p < 0.035$) and Syphilis ($p < 0.11$). In contrast, male donors had comparatively higher frequencies of HBV ($p < 0.001$) and HCV ($p < 0.011$). Multiple Infections were observed at higher frequency in male donors but without statistically significant.

We also observed an association with a statistically significant transfusion-transmitted infections seropositivity ($p < 0.001$) between age categories (Table 4). In contrast, Syphilis was higher in donors aged 35–39 and ≥ 40 years. Markers for Hepatitis C were more prevalent in donors 25–29 and ≥ 40 years. Family Blood Donors had a higher frequency of transfusion-transmitted infections than Voluntary Non-Remunerated Blood Donors (97.6% vs. 2.4 %). The prevalence of transfusion-transmitted infections markers was significantly higher in Family Blood Donors compared to Voluntary Non-Remunerated Blood Donors: (50.4% vs. 40.9 %, $p < 0.126$ for Hepatitis B); for Hepatitis C (5.2% vs. 3.0, $p < 0.774$); for HIV (7.1% vs. 3.0 % $p < 0.323$) and Syphilis 20% vs. 19.2 %, $p < 0.894$, but not a statistically significant. The frequency of coinfection was significantly higher in Family Blood Donors (74.2% vs. 62.1 %) and statistically significant $p < 0.028$.

The trend of hepatitis B, hepatitis C, HIV and Syphilis

The prevalence of Hepatitis B, hepatitis B virus core antibody (anti-HBc) and HIV was statistically significantly different by year ($p < 0.001$), and the years with the highest record were 2012 for HBV, 2013 for HIV and 2016 for anti-HBc. However, the prevalence of HCV was relatively similar in most of the years and declined in 2016. The prevalence of Syphilis, which increased in most years, was observing its highest record in 2012, and the difference in the prevalence of Syphilis was statistically significant by year ($p < 0.001$). Multiple Infections were statistically significant by year, but they started to increase by 2015 (Table 2). The overall difference in the prevalence of transfusion-transmitted infections was statistically significant by year ($p < 0.001$). The frequency of anti-*T. pallidum* antibodies were higher in donors above 35–39 and ≥ 40 years and lowest in donors aged < 25 and 34, as shown in Table 4.

Table 2 – Transfusion Transmitted Infections (TTI) positivity rate among the donors by year (June 2011 – June 2016).

	2011 (%)		2012 (%)		2013 (%)		2014 (%)		2015 (%)		2016 (%)		Total	p-value
HIV														< 0.001
Negative	264	94.0 %	390	94.2 %	364	88.8 %	354	90.1 %	397	90.2 %	774	97.2 %	2543 (93 %)	
Positive	17	6.0 %	24	5.8 %	46	11.2 %	39	9.9 %	43	9.8 %	22	2.8 %	191 (7 %)	
AgHBs														< 0.001
Negative	25	8.9 %	141	34.1 %	169	41.2 %	150	38.2 %	196	44.5 %	680	85.4 %	1361 (49.7 %)	
Positive	256	91.1 %	273	65.9 %	241	58.8 %	243	61.8 %	244	55.5 %	116	14.6 %	1373 (50.3 %)	
HCV														0.004
Negative	265	94.3 %	384	92.8 %	385	94.6 %	366	93.6 %	413	93.9 %	775	97.5 %	2588 (94.8 %)	
Positive	16	5.7 %	30	7.2 %	22	5.4 %	25	6.4 %	27	6.1 %	20	2.5 %	140 (5.2 %)	
Syphilis														< 0.001
Negative	75	93.8 %	156	58.9 %	211	65.7 %	263	74.9 %	347	80.7 %	696	94.4 %	1748 (80 %)	
Positive	5	6.3 %	109	41.1 %	110	34.3 %	88	25.1 %	83	19.3 %	41	5.6 %	436 (20 %)	
Total														< 0.001
Negative	2	0.7 %	4	1.0 %	8	2.0 %	13	3.3 %	71	16.1 %	616	77.4 %	714 (26.1 %)	
Positive	279	99.3 %	410	99.0 %	402	98.0 %	380	96.7 %	369	83.9 %	180	22.4 %	2020 (73.9 %)	
Infection														
Mono Infection	264	94.6 %	384	93.7 %	385	95.8 %	365	96.1 %	341	92.4 %	162	90.0 %	1901(94.1 %)	
Dual and Triple - Infections (MI)	15	5.4 %	26	6.3 %	17	4.2 %	15	3.9 %	28	7.6 %	18	10.0 %	119 (5.9 %)	

Hepatitis B virus surface Antigen (HBsAg), Hepatitis C virus antibody, Human Immunodeficiency Virus Type 1/2 antibody (anti-HIV). p-value, Pearson Chi-Square test for statistical difference in the distribution with each group. MI (Multiple Infection): corresponds to dual or co and triple infections.

Coinfection

Five point nine (5.9 %) of blood donors had multiple infections, 5.8 % had coinfections, and 0.1 % had triple infections. Of the coinfected donors, the most dominant were positivity Hepatitis B virus surface antigen ($HBsAg^+$)/Syphilis and $HBsAg^+/HIV^+$. A single donor presented triple infection, with positivity for $HBsAg^+$, anti-HCV^+ and anti-HIV^+. The most prevalent coinfections are Hepatitis B/Hepatitis C and HIV/Syphilis.

A statistically significant association was also observed between age categories in coinfected blood donors and transfusion-transmitted infections seropositivity ($p < 0.001$). The data shows that among the population of blood donors according to age group, it is evident that the coinfection was more prevalent in the age group of 35–39 years and donors above 40 years. Males in mono-infections constituted most coinfections of the replacement donors who had at least one transfusion-transmitted infection, and females made up slightly less than males among volunteer donations, but this was not statistically significant ($p < 0.15$). The year-to-year fluctuations in the overall prevalence of coinfections of transfusion-transmitted infections were all statistically significant ($p < 0.001$) Table 5.

Table 3 – Transfusion-Transmitted Infections (TTI) positivity rate among the donors by sex.

Infectious agent	Female, n (%)		Male, n (%)		Total, n (%)		p-value
HIV							0.035
Negative	240	89.9 %	2303	93.4 %	2543	93 %	
Positive	27	10.1 %	164	6.6 %	191	7.0 %	
AgHBs							< 0.001
Negative	160	59.9 %	1201	48.7 %	1361	49.8 %	
Positive	107	40.1 %	1266	51.3 %	1373	50.2 %	
HCV							0.011
Negative	262	98.1 %	2326	94.5 %	2588	95 %	
Positive	5	1.9 %	135	5.5 %	140	5 %	
Syphilis							0.113
Negative	163	75.8 %	1585	80.5 %	1748	80 %	
Positive	52	24.2 %	384	19.5 %	436	20 %	
Total							0.052
Negative	83	31.1 %	631	25.6 %	714	26 %	
Positive	184	68.9 %	1836	74.4 %	2020	74 %	
Infections							0.207
Mono Infection	177	96.2 %	1724	93.9 %	1901	94.1 %	
MI	7	3.8 %	112	6.1 %	119	5.9 %	

Hepatitis B virus surface antigen (HBsAg), Hepatitis C virus antibody, Human Immunodeficiency Virus Type 1/2 antibody. p-value, Pearson Chi-Square test for statistical difference in the distribution with sex. MI, Multiple Infections, corresponds to dual or co and triple infections.

Table 4 – Transfusion-Transmitted Infections (TTI) positivity rate among the donors by age group.

	< 25		25–29		30–34		35–39		≥40		p-value
HIV, n (%)											0.019
Negative	559	94.7 %	622	91.7 %	507	94.1 %	347	89.9 %	508	93.9 %	
Positive	31	5.3 %	56	8.3 %	32	5.9 %	39	10.1 %	33	6.1 %	
AgHBs, n (%)											< 0.001
Negative	187	31.7 %	318	46.9 %	265	49.2 %	247	64.0 %	344	63.6 %	
Positive	403	68.3 %	360	53.1 %	274	50.8 %	139	36.0 %	197	36.4 %	
HCV, n (%)											< 0.001
Negative	571	96.8 %	642	94.7 %	519	96.5 %	367	95.8 %	489	90.7 %	
Positive	19	3.2 %	36	5.3 %	19	3.5 %	16	4.2 %	50	9.3 %	
Syphilis, n (%)											< 0.001
Negative	404	91.0 %	476	88.1 %	360	81.8 %	229	72.9 %	279	62.6 %	
Positive	40	9.0 %	64	11.9 %	80	18.2 %	85	27.1 %	167	37.4 %	
Total, n (%)											< 0.001
Negative	118	20,0 %	191	28.2 %	156	28.9 %	124	32.1 %	125	23.1 %	
Positive	472	80.0 %	487	71.8 %	383	71.1 %	262	67.9 %	416	76.9 %	
Infection, n (%)											
Mono-infection	451	95.6 %	458	94.0 %	361	94.3 %	245	93.5 %	386	92.8 %	0.514
MI	21	4.4 %	29	6.0 %	22	5.7 %	17	6.5 %	30	7.2 %	

Hepatitis B virus surface antigen (HBsAg), Hepatitis C virus antibody, Human Immunodeficiency Virus Type 1/2 antibody. p-value, Pearson Chi-Square test for statistical difference in the distribution by age group. MI (Multiple Infection): corresponds to dual or co and triple infections.

There was a significant difference in coinfection with Hepatitis B, Hepatitis C, HIV and Syphilis concerning age groups and a year of a collection with a p-value < 0.001, but no statistical significance was observed in sex ($p < 0.150$). 2016 was the year with the highest blood donation, and they did not present any infection, and 2011 was the year that the donors had at least one transfusion-transmitted infection.

Discussion

The overall cumulative frequency of transfusion-transmitted infections markers in blood donors was 73.9 %, of which HBV, HCV, HIV and Syphilis account for 50.2 %, 5.1 %, 7 %, and 20 %, respectively. The results demonstrate a higher prevalence of transfusion-transmitted infections than previous studies in Angola, which reported an overall transfusion-transmitted infections prevalence of 25.5 %[4] and 18 %[8] in the general population and 66.5 % in women undergoing antenatal care.[9] This study showed an increase, with 50.2 % for HBV and 5.1 % HCV, and when compared to a study carried out in Namibia and Ethiopia, showed a low prevalence rate of 1.3 %[10] and 11.5 %, respectively.[11] The Hepatitis B, Hepatitis C, HIV, and Syphilis markers were more prevalent in men with 90 %, and this is observed in the other studies in different sub-Saharan African Countries, Nigeria,[12] Malawi,[13] Sierra Leone,[14] Democratic Republic of Congo,[15] Cameroon,[16]

Table 5 – Prevalence of coinfection among the population of blood donors according to age group.

	Infection			
	Without, n (%)	Mono-infection, n (%)	Coinfection, n (%)	Triple infection, n (%)
Age group				
< 25 (*n* = 590)	118 (20.0 %)	451 (76.4 %)	21 (3.6 %)	0 (0 %)
25–29 (*n* = 678)	191 (28.2 %)	458 (67.6 %)	29 (4.3 %)	0(0 %)
30–34 (*n* = 539)	156 (28.9 %)	361 (67 %)	22 (4.1 %)	0 (0 %)
35–39 (*n* = 386)	124 (32.1 %)	245 (63.5 %)	17 (10.1 %)	0 (0 %)
≥ 40 (*n* = 541)	125 (23.1 %)	386 (71.3 %)	29 (5.4 %)	1(0.2 %)
p-value		**< 0.001**		
Sex				
Female	83 (31.1 %)	177 (66.3 %)	7 (2.6 %)	0 (0.0 %)
Male	631 (2.6 %)	1724 (6.9 %)	111 (4.5 %)	1 (0.0 %)
p-value		**< 0.150**		
Year				
2011 (*n* = 281)	2 (0.7 %)	264 (94.0 %)	15 (5.3 %)	0 (0.0 %)
2012 (*n* = 414)	4 (1.0 %)	384 (92.8 %)	26 (6.3 %)	0 (0.0 %)
2013 (*n* = 410)	8 (2.0 %)	385 (93.3 %)	17 (4.1 %)	0 (0.0 %)
2014 (*n* = 393)	13 (3.3 %)	365 (92.9 %)	15 (3.8 %)	0 (0.0 %)
2015 (*n* = 440)	71 (16.1 %)	341 (77.5 %)	28 (6.4 %)	0 (0.0 %)
2016 (*n* = 796)	616 (77.4 %)	162 (20.4 %)	17 (2.1 %)	1 (0.1 %)
p-value		**< 0.001**		

Ethiopia.[11] A lower percentage of positive transfusion-transmitted infection markers was found in females; young adults are the most prevalent age group.

A high prevalence was observed in Family Blood Donors, with 97.6 % compared to Voluntary Non-Remunerated Blood Donors. Another study conducted on the Egyptian population observed a rate of 87.7 % for Family Blood Donors,[17] Eastern Ethiopia at 98 %,[11] India at 85.2 %[18] and Thailand[17] at 71 %.

Hepatitis B was the most prevalent type of transfusion-transmitted infection throughout the 5 years, with 50.2 %. This data shows a low prevalence when compared to other studies conducted in other African countries, such as Tanzania at 86.9 %[19] and a high prevalence when compared with Nigeria at 26.6 %,[20] South-West Nigeria at 18.6 %,[12] Mali 13.9 %.[21] Other countries of Africa with a similarly high seroprevalence of HBV in BD are, for example, Benin, with 46.83 %[22] and over 20 % Tunisia.[23]

On the other hand, 731 (62,9 %) donors were positive for Hepatitis B core antibody (anti-HBc), which, nonetheless, is lower than a study conducted in Kinshasa, with 70.9 % of anti-HBc prevalence.[24] The HBV-OBI (Occult Hepatitis B Infection) were classified as possible because they were negativity Hepatitis B virus surface antigen ($HBsAg^-$), but the HBV-DNA (Desoxyribonucleic Acid) was not carried out. Therefore, these donors were soon excluded from the first and can be studied in the future.

Hepatitis C was 5.1 %; similarly, the prevalence was found in a study pilot in Burkina Faso at 5.2 % and high in Nigeria at 6.0 %,[12,25] 6.2 % in Gabon,[26] 8 % in Tanzania,[27] and 8.5 % in South Ethiopia.[28] Studies conducted in the Central Africa Republic,[29] Burkina Faso,[30] and South Gondar-Ethiopia[31] have shown a low seroprevalence of HCV with 4.72 %, 4.40 % and 4.2 %, respectively. Other countries with low seroprevalence were Morocco with 1.51 %,[32] Ethiopia with 1.6 %[33] and Namibia with 0.1 %.[10]

According to the study, the prevalence of HIV in the blood donors population was 7 %. The proportion is considerably higher than other studies conducted elsewhere in Africa, like South Ethiopia, at 6.4 %,[28] Egypt at 0.01 %,[17] and Nigeria at 4.2 %[34] and lowest when compared to Mozambique at 8.5 %,[35] Equatorial Guinea at 7.83 %,[36] South Africa at 9.8 %,[37] Zambia at 15.9 %,[38] Botswana at 22.9 %, Namibia at 9.1 %, and Swaziland at 26.1 %.[39]

The prevalence of Syphilis was 20 %, and when compared to other studies conducted in other African countries, Equatorial Guinea showed the highest prevalence of *T.pallidum,* 21.51 %[36] and 40.5 % in Zambia.[40] Three countries present a lower prevalence: Cameroon at 8.1 %,[41] Ghana at 7.5 %,[42] and Tanzania at 4.7 %.[43] A study carried out in Namibia on Syphilis shows it to be more prevalent in women,[10] which contradicts the findings of this study.

One of the main limitations of this study is that it was conducted with donations over five years. It is a retrospective blood donation card review, which might not include some variables. All test results did not give positive serological results during the window period, and it would be crucial for the study to cover other institutions by analysing the donors' characteristics for several years with a much larger population for a more extended period. Many other studies should be done in Angola to assess the evolution of infections. The analysis of this study should be performed in several contexts for easy comparison with other studies. However, the data categorisation based on this study indicated the origin of most transfusion-transmitted infections.

We estimated a high seroprevalence of transfusion-transmitted infections among blood donors in Angola. Our study showed increased Hepatitis B prevalence and Syphilis and poor women participation. Identifying the seroprevalence of markers with positive results for Hepatitis B, Hepatitis C, HIV, Syphilis, and coinfection in blood donors is crucial to contribute to a strategy that can better control the transmission of these diseases, especially coinfection. The difficulty of obtaining safe blood has been well demonstrated, which raises the need for more accurate and statistical studies to establish better health policies for transfusion safety.

Conclusion

The present study shows a high seroprevalence of transfusion-transmitted infections among blood donors at Clínica Girassol in Luanda in the Angola Region. These trends of Hepatitis B, Hepatitis C, HIV and Syphilis prevalence suggest that it is crucial to be rigorous in implementing safety measures. Our study showed that it is essential to encourage more donations in voluntary donors for blood donation activities. Surveillance, control and prevention require continuous monitoring of the transmission of Hepatitis B, Hepatitis C, HIV and Syphilis, so it is imperative to improve the screening of donor selection criteria and the use of a combination of donor selection methods that provide safe blood in our country and thus contribute to the reduction of prevalence.

Author's contributions

All the authors participated, read, and approved the final manuscript.

Cordeiro BL, Dias CC, Altamiro CP, and António Sarmento were involved in the conception and design of the study, interpretation of data, and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Ethical consideration

This study was approved by the Institutional Ethics Committee (National Institute of Public Health of the Ministry of Health of Angola 25/2017) and (approval number 04/2018).

The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.

Written informed consent was obtained from each participant and all donors signed an informed consent form for study participation and data publication.

Conflicts of interest

The authors declare no conflicts of interest.

Funding

The authors declare that they have not received any funding.

Acknowledgements

The authors wish to thank all employees of the Immunohemotherapy Service of the Clínica Girassol who, in one way or another, contributed to the collection of data for statistical analysis.

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PUBLICAÇÃO 2

Seroprevalence of Hepatitis B Virus Surface Antigen among African Blood Donors: A Systematic Review and Meta-analysis. ***Angelina Edna Quintas***, Nelson Cuboia, Lemuel Cordeiro, António Sarmento, Luís Azevedo

(Publicado na revista *Frontiers in Public Health* em 21 de outubro de 2024)

frontiers | Frontiers in Public Health

TYPE Systematic Review
PUBLISHED 21 October 2024
DOI 10.3389/fpubh.2024.1434816

OPEN ACCESS

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RECEIVED 19 May 2024
ACCEPTED 08 October 2024
PUBLISHED 21 October 2024

CITATION
Quintas AE, Cuboia N, Cordeiro L, Sarmento A and Azevedo L (2024) Seroprevalence of Hepatitis B virus surface antigen among African blood donors: a systematic review and meta-analysis. *Front. Public Health* 12:1434816. doi: 10.3389/fpubh.2024.1434816

Seroprevalence of Hepatitis B virus surface antigen among African blood donors: a systematic review and meta-analysis

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Background: Transfusion Transmitted Infections (TTIs) are still a growing public health problem in Africa. Studies that synthesize the available evidence on the seroprevalence of Hepatitis B Surface Antigen (HBsAg) among African blood donors are scarce. Therefore, this study aimed to synthesize qualitatively and quantitatively the seroprevalence of Hepatitis B Virus Surface Antigen (HBsAg) among blood donors in Africa.

Methods: We conducted a systematic review and meta-analysis where we included all studies that reported the seroprevalence of HBsAg among blood donors in Africa. The references were searched from electronic databases: PubMed, Web of Science, Cochrane, Scopus, WHO research database-HINARI, Global Index Medicus and ClinicalTrials.gov. We further analyzed the full list of references of all included studies. The pooled seroprevalence was estimated through random effect model. The heterogeneity was assessed through Cochrane's Q test and I^2, respectively. Meta-regression, subgroup and sensitivity analyses were conducted.

Results: We obtained 124 studies that met our inclusion criteria, comprising 3,573,211 blood donors tested for HBsAg. The pooled seroprevalence of HBsAg among blood donors in Africa was 6.93% (95% CI: 5.95–7.97%; $I^2 = 100\%$; $p < 0.001$). We found that the heterogeneity was explained by the study performed country and, African region. The higher prevalence was observed in Western 10.09% (95% CI: 8.75–11.50%), Central 7.81% (95% CI: 5.34–10.71%), and Eastern African region 4.87% (95% CI: 3.77–6.11%) and lower prevalence were observed in Southern 2.47% (95% CI: 0.54–5.75%) followed by Northern Africa region with 1.73% (95% CI: 0.45–3.79%). Additionally, based on the date of publication, we found that the highest prevalence was observed in studies published between 2001 and 2010 (9.41, 95% CI: 7.19–11.90) and the lowest prevalence was observed in studies published between 2011 and 2024 (6.26%; 95% CI: 5.19–7.42).

Conclusion: The seroprevalence of HBsAg among blood donors in Africa is still very high and heterogeneous. Therefore, intensifying the screening and vaccination of the population for Hepatitis B is critical to ensure blood safety toward eliminating Hepatitis B in Africa.

Systematic review registration: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=395616, PROSPERO CRD42023395616.

KEYWORDS

blood donors, seroprevalence, serologic tests, Hepatitis B virus, African countries

Introduction

Hepatitis B Virus (HBV) remains one of the most serious public health concerns challenging the world, with an estimated 257–291 million individuals having chronic Hepatitis B (1). Africa is one of the highest-burden regions for Hepatitis B, where it is estimated that nearly 116 million people live with Hepatitis B and 81 million are chronically infected (2). An infected person can transmit HBV through direct contact with blood, unprotected sexual intercourse, use of contaminated needles and syringes, mother to child transmission during delivery, and transfusion of infected blood (3). Transfusion of infected blood is one of the main modes of HBV transmission, particularly in the sub-Saharan Africa region (4). Therefore, the World Health Organization (WHO) recommends that all countries provide access to screening and preventive measures such as vaccination and treatment for Hepatitis B (5).

Blood transfusion can be potentially lifesaving, but the risk of several Transfusions-Transmissible Infections (TTIs) such as Hepatitis B is high. For this reason, screening of blood donors for TTIs is essential for transfusion safety.

Although more sensitive tests are highly recommended for screening Hepatitis B among blood donors, most of lower- and middle-income countries still widely use rapid diagnostic tests. These methods are still indispensable to guarantee blood donation safety in many African countries (6). To maintain a safe supply of blood transfusion and products, the WHO recommends that all blood donations be screened for infections before use (7).

Several systematic reviews and meta-analyses have estimated the prevalence of hepatitis B among blood donors in some specific African countries (8–12). However, comprehensive studies on the prevalence of Hepatitis B among blood donors in Africa are scarce. Therefore, this study aimed to systematically synthesize the available evidence on the seroprevalence of Hepatitis B Virus Surface Antigen (HBsAg) among Blood Donors in Africa.

Abbreviations: AIDS, Acquired immunodeficiency syndrome; Anti-HBc, Hepatitis B virus core antibody; Anti-HCV, Hepatitis C virus antibody; Anti-HCV+, Hepatitis C virus antibody positive; Anti-HIV, Human Immunodeficiency Virus antibody; BD, Blood donors; ELISA, Enzyme-linked immunosorbent assay; FRBD, Family replacement blood donor; HBV, Hepatitis B virus; HBV-OBI, Occult Hepatitis B infection; HBsAg, Hepatitis B virus surface antigen; HBsAg-, Hepatitis B virus surface antigen negative; HBsAg+, Hepatitis B virus surface antigen positive; HCV, Hepatitis C virus; HIV, Human immunodeficiency virus; HIV-1, Human immunodeficiency virus type 1; HIV-2, Human immunodeficiency virus type 2; QGIS, Quatum geo graphic information system; STDs, Sexually transmitted diseases; TPHA, *Treponema pallidum* hemagglutination assay; *T pallidum*, *Treponema pallidum*; TTIs, Transfusion-transmitted infections; VDRL, Venereal Disease Research Laboratory; VNR, volunteer's non-remunerated; VNRBD, volunteer's non-remunerated blood donors; WHO, World Health Organization.

Methods

Study design

This study is a systematic review and meta-analysis based on The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA Statement Guideline updated in 2020) (13). The study protocol was registered in the PROSPERO with the number CRD42023395616.

Search strategy and study selection

We included primary studies published in any language from inception through March 1st 2024, and having extractable data on seroprevalence of HBsAg among blood donors in Africa aged 16–65. We excluded case series, reviews, comments, editorials, and studies with duplicate data.

All relevant articles were searched in electronic databases, namely: PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus and Clinicaltrials.gov. The research query is in the Supplementary Table S1. We further analyzed systematically the full list of references of all included studies.

Two reviewers (AEQ, NC) carried out the study selection process independently, and discrepancies were resolved by the third reviewer (LA). This study was part of a more extensive research project that assessed the seroprevalence of Serologic Markers of Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Human Immunodeficiency Virus (HIV), and Syphilis in Blood Donors in Africa.

Due to the considerable volume of results, we decided to split such a study into four separate analyses based on the transmitted blood infection disease (Hepatitis B virus, Hepatitis C Virus, Syphilis, and HIV).

Data extraction

Two reviewers, AEQ and NC independently extracted the data for each included study based on a predefined and agreed-upon data extraction form designed for this study. The differences in extracted data were discussed, and persistent discrepancies were resolved by a third reviewer (LA). For each included study, we extracted the following information: Author name, year of publication, date of participant enrolment, study design, name of the country and African region where the study was performed, the total number of participants for each study, the total number of blood donors who tested positive for HBsAg, age, sex, type of blood donors (VNRBD-Voluntary Non-Remunerated Donors, RD- Replacement or Paid Donors/FD and FD-Family Donors), and the method used for screening and Hepatitis B diagnosis. This data was stored in a

Microsoft Excel 2021 spreadsheet (Microsoft Corporation, Redmond, Washington, USA).

Study's quality assessment

Two reviewers, AEQ and NC, independently assessed the quality of each included study using the risk of bias tool SeroTracker-RoB: a decision rule-based algorithm for reproducible risk of bias assessment of seroprevalence studies (14). The differences in the quality assessment of the included studies were discussed, and persistent disagreements were resolved by the third reviewer (LA). This tool derives from the Joanna Briggs Institute Checklist for Prevalence Studies and asks nine questions to assess the risk of bias. The questions are (a) Was the sample frame appropriate to address the target population? (b) Were study participants recruited in an appropriate way? (c) Was the sample size adequate? (d) Was the data analysis conducted with sufficient coverage of the identified sample? (e) Were valid methods used for the identification of the condition? (f) Was the condition measured in a standard, reliable way for all participants? (g) Was there appropriate adjustment for test characteristics? (h) Was there appropriate adjustment for population characteristics? (i) Was the response rate adequate, and if not, was the low response rate unlikely to introduce bias? And the last was the assessment of the overall risk of bias (lower, moderate, high and unclear) according to the scores from the responses of the previous nine items.

Data analysis

All the data were analyzed through R software version 4.3.2 (2023-10-31) using meta package and the functions for meta-analysis of proportion (15). We used the proportion of blood donors who tested positive for HBsAg as the parameter of interest to be estimated as our effect measure and meta-analyzed. We used the DerSimonian-Laird random effects model to estimate the pooled seroprevalence of HBsAg among blood donors in Africa, and the proportions were estimated based on Freeman-Tukey double arcsine transformation (FTT) (16). The findings were presented with 95% confidence intervals.

We run a Cochrane Q test and I^2 statistic (percentage of total variability due to true heterogeneity, that is, to between-studies variability) to assess the presence of heterogeneity and its relative magnitude, respectively (17). We performed subgroup and sensitivity analysis to investigate the moderator variables of the observed heterogeneity. Because we are analyzing and synthesizing prevalence studies from all of Africa and several different countries, we inherently assumed the presence of heterogeneity, and we mainly focused our analysis and results on subgroups and the assessment of moderators of heterogeneity.

The subgroup analysis studies were stratified by the country, African region, and year of publication. The years of publication were categorized into three categories (before 2000, 2001–2010 and 2011–2024). This cut-off was chosen based on the behavior of the distribution of the number of studies by year. To determine the moderators of heterogeneity, temporal trends and regional differences in our study, we performed meta-regression analyses using the following variables: year of study publication and African region (Western, Northern, Eastern, Central, and Southern), risk of bias, study location (unicentric and multicentric), setting (Urban and Rural), proportion of men, age, type of blood donors and country where the study was performed. In our study, we defined study location as unicentric if the study was carried out in a single center or one hospital. In contrast, a multicentric study means the study was conducted in multiple centers or hospitals. The setting variable refers to whether the study was conducted in an urban or rural area.

The publication bias was assessed through a funnel plot and by Egger's statistics regression test. We mapped the spatial pattern of the pooled estimates of seroprevalence of HBsAg among blood donors in Africa by country. The map was created using Quantum Geographic Information System (QGIS) software (18).

Results

A total of 4,408 were identified through database and manual searching, and 500 duplicate articles were removed. The title and abstract of the remaining 3,908 were screened, and 3,605 articles were removed as they were found to be irrelevant to our study. The remaining 303 references were assessed for eligibility through the complete text examination, and 179 were excluded because they did not meet our inclusion criteria. The remaining 124 studies were considered for qualitative and quantitative synthesis involving 3,573,211 participants.

Among 179 that did not meet our inclusion criteria, 77 did not study the prevalence of Hepatitis B among blood donors, 43 were systematic reviews, 16 studies did not have relevant data, five studies did not have their full text available, 12 studies included population already positive to Hepatitis B, 12 studies included children, 14 studies included pregnant women (See Figure 1; Supplementary Table S3).

Study characteristics

Supplementary Table S2 shows the characteristics of the studies included in this work. Thirty (55.5%) of the 54 African countries are represented in the 124 studies included. Most of the studies were conducted in Western Africa 51 (41.13%), followed by Eastern Africa 32 (25.81%), then by Central 26 (20.97%), and lastly by the Northern 9 (7.26%) and Southern 6 (4.84%) African region.

The year of study publication ranged from 1990 to 2024. The majority, 89 (75%), were published after 2010. The median proportion of men in the included studies was 83.75%.

Regarding the risk of bias, most studies had a moderate risk of bias 70 (56.45%), followed by a low risk of bias 36 (29.03%), and lastly by a high risk of bias 18 (14.52%).

Seroprevalence of hepatitis B surface antigen

We found that the pooled seroprevalence of HBsAg among blood donors in Africa was 6.93% (95% CI: 5.95–7.97%; see the forest plot in Figure 2).

In subgroup analysis, we found statistically significant differences in the seroprevalence of HBsAg among blood donors in Africa

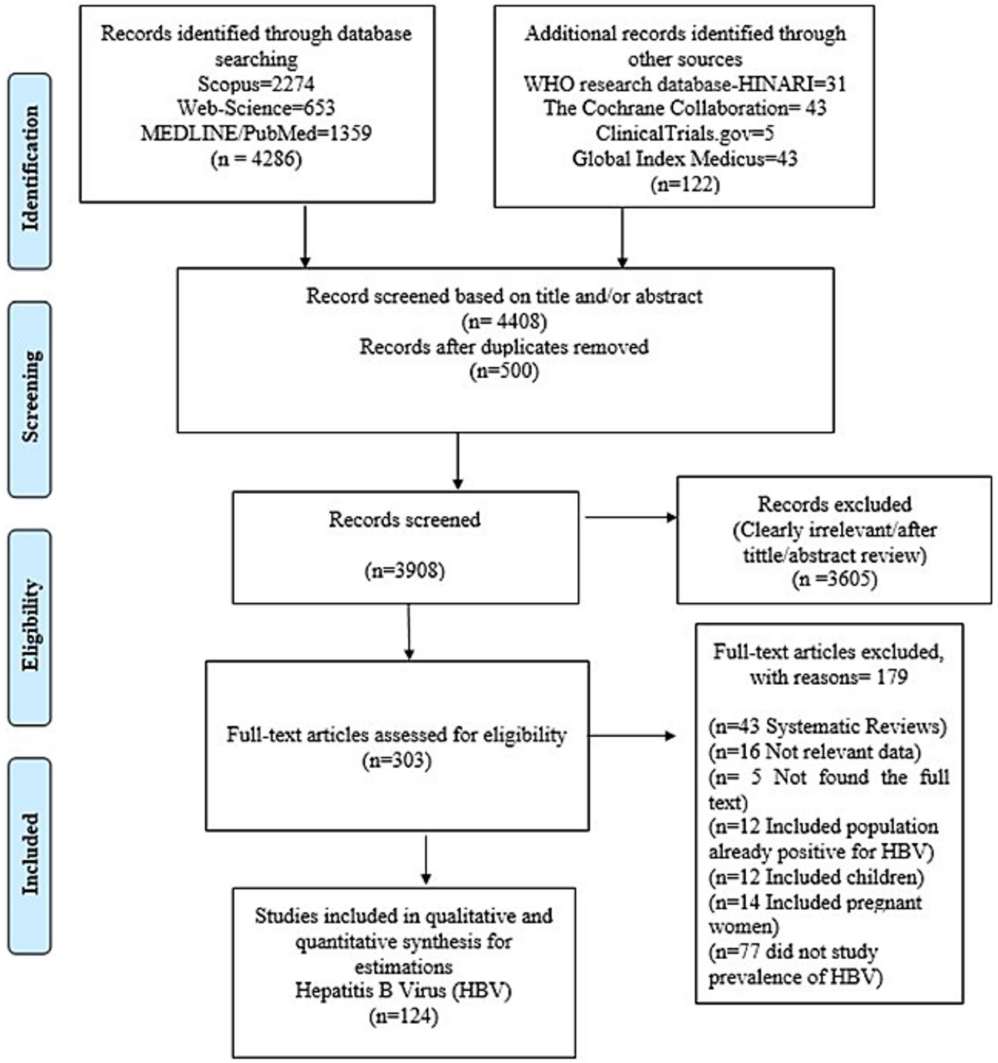

FIGURE 1
PRISMA flow diagram of studies reviewed, screened, and included.

according to the study country ($p < 0.01$), year of study publication ($p < 0.03$) and African region ($p < 0.01$), (Figures 2, 3; Table 1).

Regarding the seroprevalence of HBsAg by African regions, we found that the Western region had the highest prevalence of HBsAg at 10.09% (95% CI: 8.75–11.50%), followed by the Central region with 7.81% (95% CI: 5.34–10.71%), then by the Eastern Africa region with 4.87% (95% CI: 3.77–6.11%) the Southern with 2.47% (95% CI: 0.54–5.75%) and finally, by the Northern African region with 1.73% (95% CI: 0.45–3.79%).

Regarding to the year of study publication, highest prevalence was observed in studies published between 2001 and 2010 (9.41%; 95% CI: 7.19–11.90%) followed by studies published from 1990 to 2000 (8.07%; 95% CI: 3.80–13.73%) and the lowest prevalence was observed in the studies published between 2011 and 2024 (6.26%; 95% CI: 5.19–7.42%) (see Table 1).

We generally found high heterogeneity among pooled studies (Cochran *Q*-test $p < 0.001$ and $I^2 = 100\%$). In the meta-regression analysis, we observed that the heterogeneity was moderated by the African region ($p < 0.01$) and the country where the study was performed ($p < 0.01$) (see Table 2).

Among the studied moderator variables, 44.69% of the heterogeneity was explained by the country where the study was performed ($p < 0.01$), and by the African region 28.60% ($p < 0.01$). We did not find a statistically significant variation in the seroprevalence

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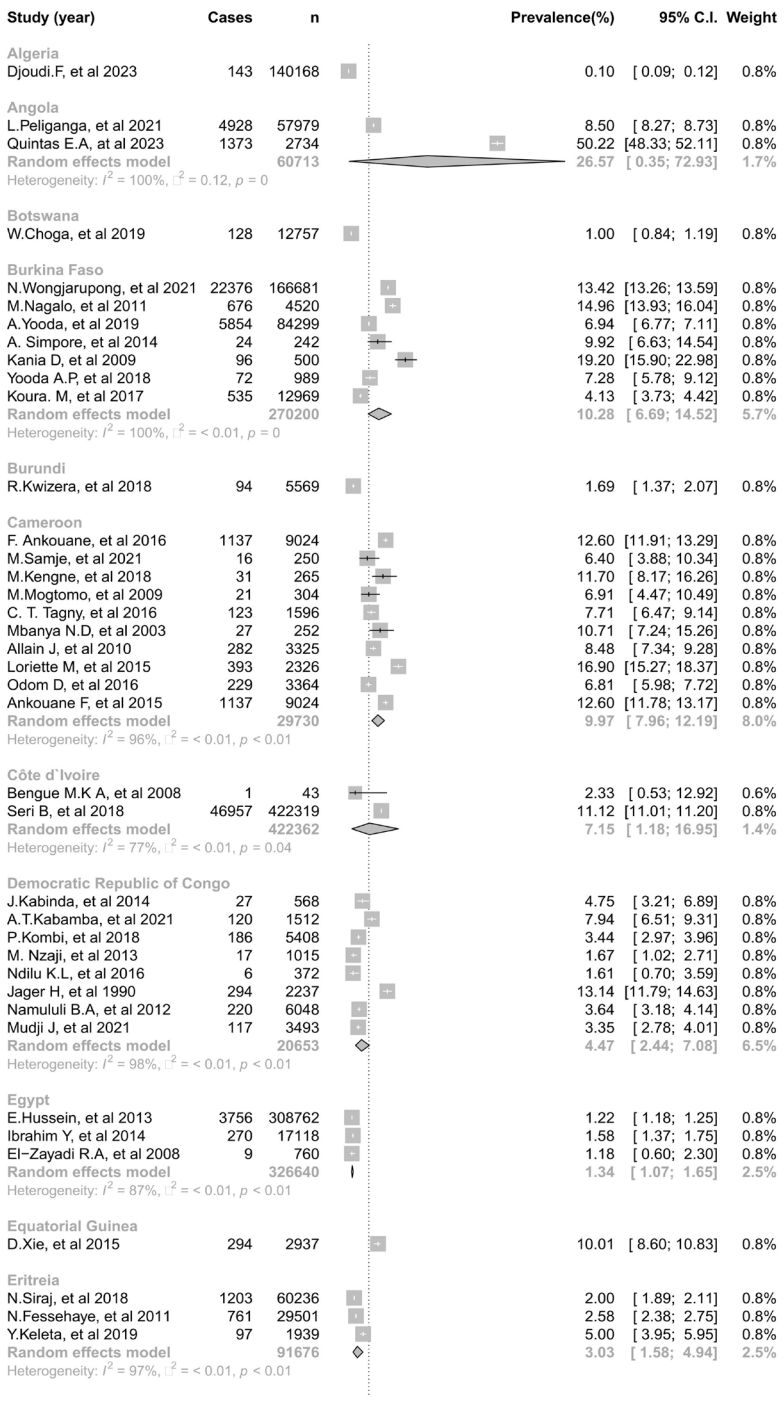

FIGURE 2 (Continued)

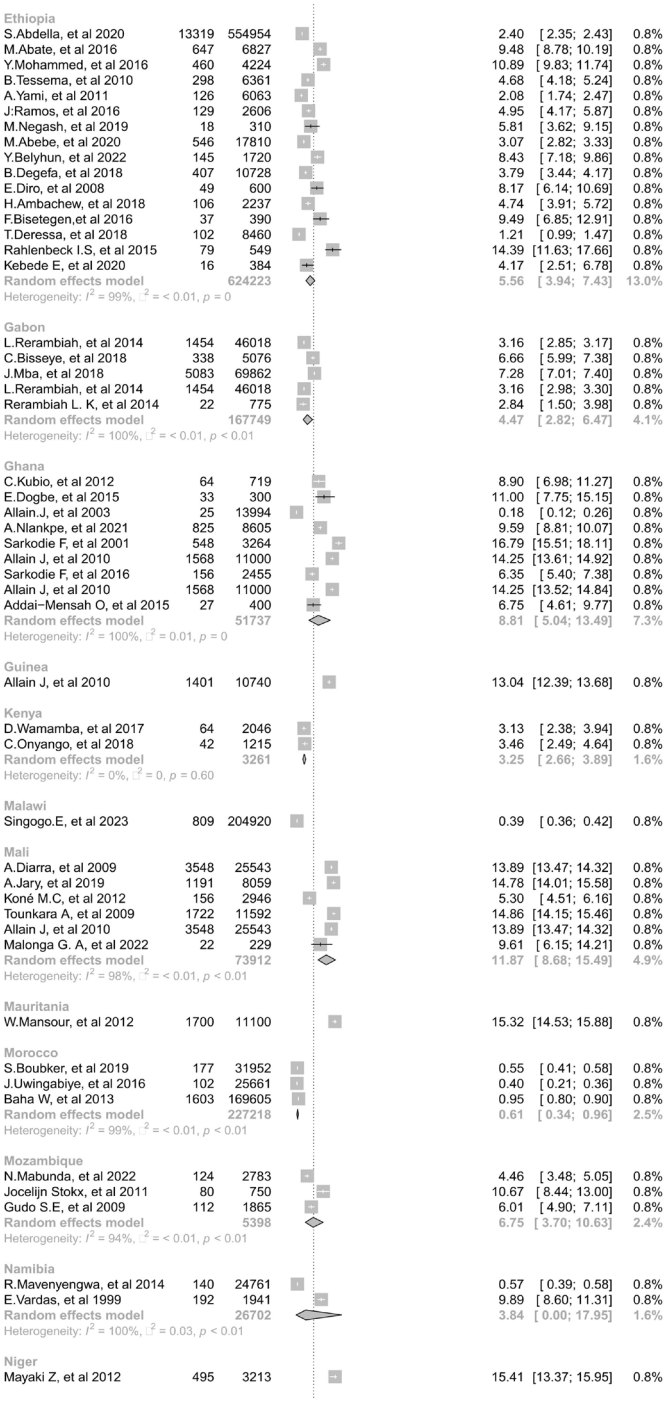

FIGURE 2 (Continued)

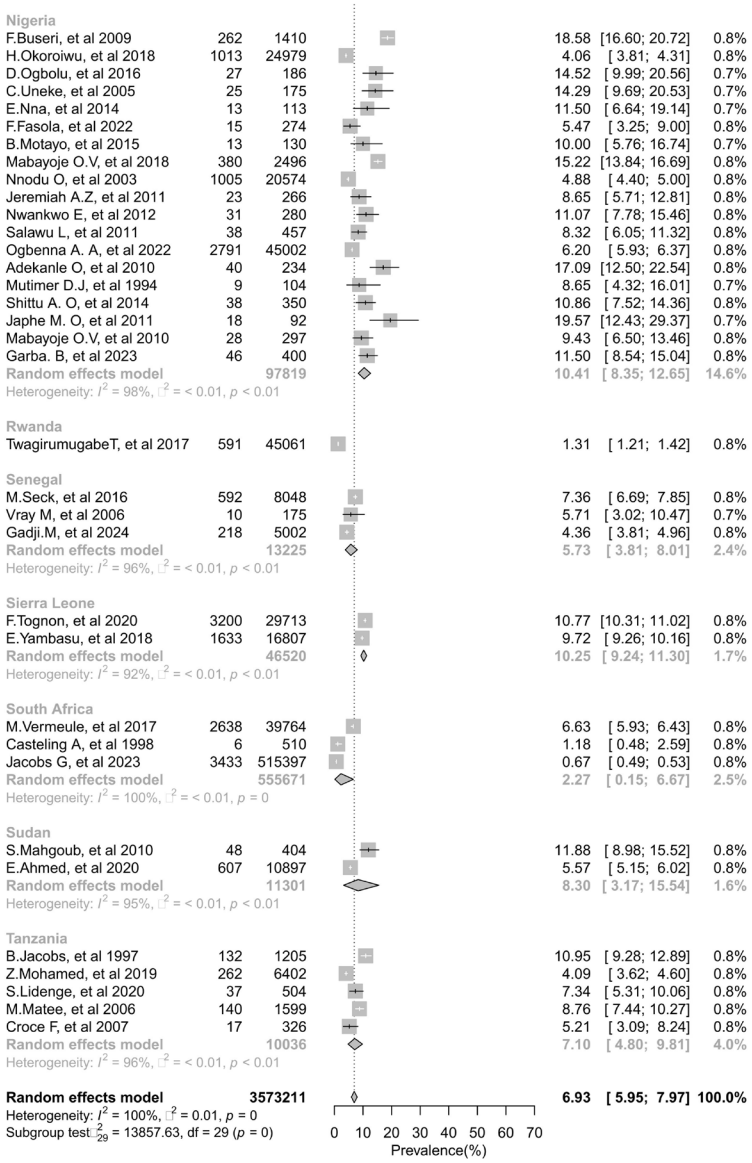

FIGURE 2
Forest plot of the pooled seroprevalence of Hepatitis B Surface Antigen among Blood donors in Africa by country, Random-effect model: subgroup analysis by region. ES estimated prevalence of HBV.

of HBsAg by the risk of bias ($p = 0.92$), study location ($p = 0.05$), setting ($p < 0.69$), year of study publication ($p = 0.07$) type of blood donor ($p = 0.64$), age ($p = 0.89$) and proportion of males ($p = 0.31$) (see Table 2).

Although the year of study publication was not statistically significant in the meta-regression analysis, we did find a decreased trend in the seroprevalence of hepatitis B among African blood donors over the years (see Figure 4).

The funnel plot showed asymmetry, and the regression Egger's test was statistically significant ($p < 0.01$). Meaning that the evidence of the presence of risk of publication bias was identified (see Figure 5).

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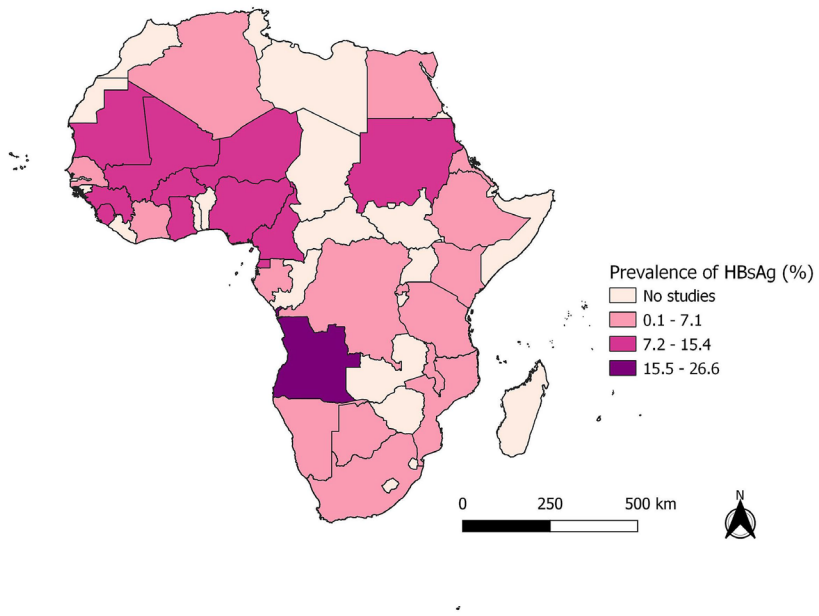

FIGURE 3
Map of the seroprevalence of Hepatitis B among blood donors in Africa.

TABLE 1 Sub-group analysis of the pooled prevalence of HBsAg estimation in African blood donors by regions (1990–2024).

Moderator variables	Category	Number of studies	Aggregate sample size	Prevalence % (95% CI)	I^2 (%)	*p*-value
Africa region	Western	51	1,000,828	10.09 (8.75; 11.50)	99.7	0.01
	Eastern	32	990,144	4.87 (3.77; 6.11)	99.7	
	Central	26	281,782	7.81 (5.34; 10.71)	99.7	
	Northern	9	705,327	1.73 (0.45; 3.79)	99.8	
	Southern	6	595,130	2.47 (0.54; 5.75)	99.9	
Year of publication	1990–2000	5	5,997	8.07 (3.80; 13.73)	96.4	0.03
	2001–2010	26	151,880	9.41 (7.19; 11.90)	99.7	
	2011–2024	93	3,415,334	6.26 (5.19; 7.42)	99.9	

I^2 = Heterogeneity; *p*-value: significance test of subgroup differences.

TABLE 2 Moderators of heterogeneity on the seroprevalence of HBsAg in blood donors in Africa.

Variables	Moderators test *p*-value	R^2 (%)
African region	< 0.01	28.60
Country	< 0.01	44.69
Risk of bias	0.92	0.0
Location	0.05	2.05
Setting	0.69	0.00
Type of Blood donors	0.64	0.00
Age	0.89	0.00
Proportion of male	0.31	0.07
Year of study publication	0.07	2.02

R^2: The amount of heterogeneity accounted for.

Discussion

Our study shows that the seroprevalence of HBsAg among blood donors in African countries was 6.93% (95% CI: 5.95–7.97%). This finding is consistent with a report on the prevalence of HBsAg in the general population in Africa, which is considered to be higher (19). This means the Hepatitis B virus remains an enormous public health problem in Africa (5). These findings are worrisome as there are reports of transmission of the Hepatitis B virus infection by blood transfusion (20, 21). The risk of becoming infected with HBV in sub-Saharan Africa from a blood transfusion is high and around 4.3 per 1,000 units (4).

In our study, the seroprevalence of HBsAg among blood donors was higher compared to data reported from the European Union, which is 1.1% among first-time blood donors (22), China 1.32% (23), Laos (Southeast Asian country) which was around 2.6% (24)

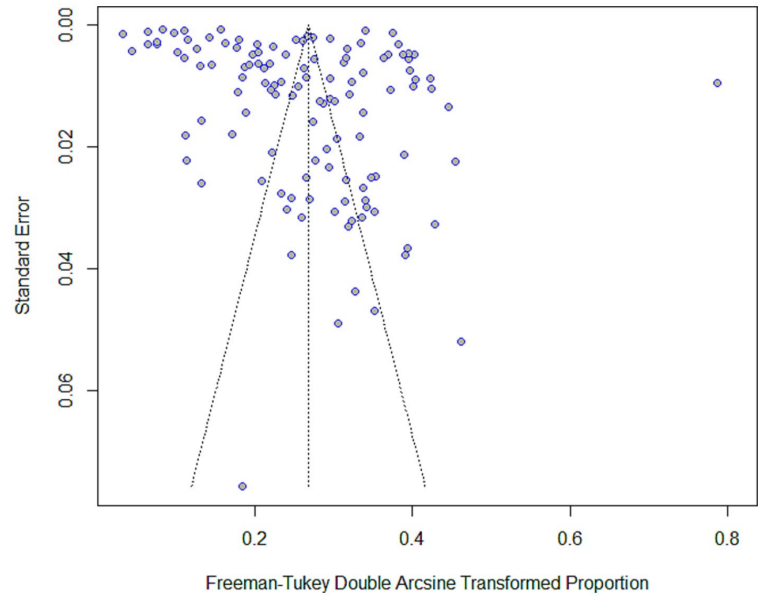

FIGURE 5
Funnel plot of the seroprevalence of HBV in African blood donors from 1990 to 2022.

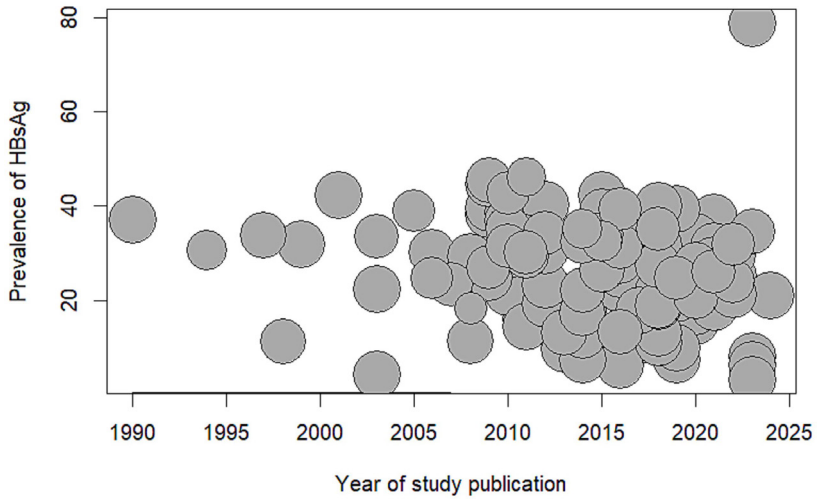

FIGURE 4
Bubble plot meta-regression of seroprevalence of Hepatitis B Surface Antigen among blood donors in Africa and year of study publication. HBsAg: Hepatitis B Surface Antigen.

and in the Eastern Mediterranean and Middle Eastern countries which were 2.03% (25).

We found statistically significant differences in the prevalence of HBsAg based on the African region where the study was performed. The Western Africa region had the highest prevalence of 10.09%, followed by the Central region (7.81%) and Eastern (4.87%), while the Southern (2.47%) and Northern African regions (1.73%) exhibited lower prevalence.

These findings are consistent with the systematic reviews and meta-analyses conducted in countries of the Western region, such as Burkina Faso (26), Kenya (27) in Eastern Africa, and Cameron (28) in the Central region of Africa, which show a higher prevalence of Hepatitis B ranging from 8 to 12%. In contrast, the low prevalence observed in the countries of Northern and Southern Africa is consistent with the epidemiological study on the prevalence of the Hepatitis B virus in Africa, which shows a low endemicity level (<2%) in the Northern region (19, 29).

We found an inverse relationship between the prevalence of Hepatitis B among blood donors in Africa and the year of the study publication, although it was not statistically significant in the meta regression analysis, we did find statistically differences in subgroup analysis splitting the year into three categories. We found that, published studies (after 2010) tended to present lower seroprevalence of Hepatitis B than studies published before 2010. This finding can be explained by the introduction of universal infant and childhood hepatitis B vaccination programs in 1997 (30) and improved screening and treatment of Hepatitis B.

Additionally, we found that the country where the study was carried out was a statistically significant moderator of the heterogeneity of the seroprevalence of HBsAg. These findings can be explained by the existing differences in the access and quality of screening procedures, the social and demographic profile of each country, lifestyle, prevalence of hepatitis B in the general population, and much more importantly, availability of vaccination and treatment services in these countries (19, 31).

Our systematic review has some limitations: The pooled seroprevalence of HBsAg among blood donors that we found cannot be generalized to the whole of Africa as 24 (44%) of African countries did not have any study on the topic. The studies overrepresented countries located in the Western, Central and Eastern regions of Africa and underrepresented those countries in the Northern and Southern regions of the continent. Therefore, further studies are needed concerning underrepresented African areas to complement our findings and to have a good overview of the seroprevalence of HBsAg in Africa. Additionally, we found higher heterogeneity among the included studies ($I^2 = 100\%$). Moreover, we found greater variation in the precision of our estimates due to differences in the total sample sizes of studies across different periods and African regions. Specifically, fewer populations were included in studies conducted in the 1990s compared to the larger number included in studies after 2001. Similarly, smaller sample sizes were observed in the Southern and Northern regions compared to the Western, Eastern, and Central African regions.

Notwithstanding the above limitations, this study has some strengths worth mentioning: to the best of our knowledge, this is the first systematic review and meta-analysis study that analyzed and synthesized the seroprevalence of HBsAg among blood donors in Africa and investigated the reasons for the variability of the prevalence of HBsAg across Africa.

Conclusion: The prevalence of HBsAg among blood donors in Africa is still very high, and it widely varies according to the country, African regions, and year of study publication. Therefore, there is a need for scale-up strategies to intensify the screening of blood donors and extend access to the Hepatitis B vaccine and improve public policy for blood transfusion safety toward Hepatitis B virus elimination.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author contributions

AQ: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. NC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. LC: Conceptualization, Supervision, Validation, Writing – review & editing, Investigation. AS: Conceptualization, Investigation, Supervision, Validation, Writing – review & editing. LA: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing, Formal analysis, Writing – original draft.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This article was supported by National Funds through FCT - Fundação para a Ciência e a Tecnologia, I.P. within CINTESIS, R&D Unit (reference UIDP/4255/2020).

Acknowledgments

The authors want to acknowledge the Department of Community Medicine, Information, and Decision in Health of the University of Porto and the Center for Health Technology and Services Research to conduct this systematic review and meta-analysis. We are grateful to the studies' authors included in this systematic review and Doctor Milaydis Sosa Napolskij, who proofread the manuscript's text.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1434816/full#supplementary-material

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MATERIAL SUPLEMENTAR

Supplementary Table S1.
Supplementary Table S2.

1 **Supplementary materials**

2 **Table S1: Research query**

Search	Query
#12	Search: **#9 OR #4 AND #5 OR #6 AND #7**
#11	Search: **#9 AND #10**
#10	Search: **#4 OR #5 OR #6 OR #7**
#9	Search: **#8 AND #3**
#8	Search: **#1 AND #2**
#7	Search: **((Syphilis OR Lues))**
#6	Search: **((Hepaciviruses OR (Hepatitis C Virus OR Hepatitis C viruses) OR (Hepatitis C-Like Virus OR Hepatitis C-Like Viruses))**
#5	Search: **((Hepatitis B virus OR Hepatitis B viruses) OR (Dane Particle OR Particle Dane) OR (Hepatitis Virus OR Homologous Serum))**
#4	Search: **((HIV OR Human Immunodeficiency Virus OR Human Immunodeficiency Viruses) OR (AIDS Virus OR AIDS Viruses) OR (Acquired Immune Deficiency Syndrome Virus OR Acquired Immunodeficiency Syndrome Virus) OR (Human T Lymphotropic Virus Type III OR Human T-Lymphotropic Virus Type III) OR (Lymphadenopathy-Associated Virus OR Lymphadenopathy Associated Virus OR Lymphadenopathy-Associated Viruses) OR (HTLV-III OR LAV-HTLV-III))**
#3	Search: **Algeria OR Angola OR ((Benin OR (Republic of Benin) OR Dahomey)) OR (Botswana OR Bechuanaland OR Kalahari) OR ((Burkina Faso OR (Upper Volta) OR (Burkina Fasso)) OR ((Burundi OR (Republic of Burundi) OR Urundi)) OR ((Cabo Verde) OR (Republic of Cape Verde) OR (Cape Verde)) OR ((Cameroon OR (Republic of Cameron) OR (United Republic of Cameroon) OR Cameroons)) OR ((Central African Republic) OR Ubangi-Shari) OR Chad OR ((Comoros OR (Iles Comores) OR (Comoro Islands) OR Mayotte)) OR ((Democratic Republic of Congo) OR Congo OR (Kinshasa) OR Zaire OR (Belgian Congo) OR Katanga)) OR ((Republic of Congo OR Republic of the Congo OR Congo (Brazzaville)) OR ((Cote d'Ivoire OR (Ivory Coast) OR (Republic of Cote diIvoire)) OR ((Djibouti OR (Republic of Djibouti) OR (French Somaliland)) OR ((Egypt OR (Arab Republic of Egypt) OR (United Arab Republic)) OR ((Equatorial Guinea OR (Republic of Equatorial Guinea)**

Search	Query
	OR (Spanish Guinea) OR (Guinea Spanish) OR (Rio Muni)) OR Eritrea OR (Eswatini OR Swaziland) OR ((Ethiopia OR (Federal Democratic Republic of Ethiopia)) OR ((Gabon OR (Gabonese Republic)) OR ((Gambia OR (Republic of the Gambia)) OR ((Ghana OR (Republic of Ghana) OR (Gold Coast)) OR ((Guinea OR (Republic of Guinea) OR (French Guinea)) OR ((Guinea-Bissau OR (Republic of Guinea-Bissau) OR (Portuguese Guinea)) OR ((Kenya OR (Republic of Kenya)) OR ((Lesotho OR Basutoland OR (Kingdom of Lesotho)) OR ((Liberia OR (Republic of Liberia)) OR Libya OR ((Madagascar OR (Malagasy Republic)) OR ((Malawi OR (Republic of Malawi) OR Nyasaland) OR ((Mali OR (Republic of Mali)) OR Mauritania OR ((Mauritius OR (Agalega Islands)) OR (Morocco OR Ifni) OR ((Mozambique OR (Republic of Mozambique) OR Mosambique OR Mocambique OR Moçambique OR (Portuguese East Africa)) OR ((Namibia OR (Southwest Africa) OR (Republic of Namibia) OR (South West Africa)) OR ((Niger OR (Republic of Niger)) OR ((Nigeria OR (Federal Republic of Nigeria)) OR ((Rwanda OR (Republic of Rwanda)) OR (Sao Tome and Principe) OR ((Senegal OR (Republic of Senegal)) OR Seychelles OR ((Sierra Leone) OR (Republic of Sierra Leone)) OR Somalia OR ((South Africa) OR (Union of South Africa) OR (Republic of South Africa)) OR (South Sudan) OR ((Sudan OR (Republic of the Sudan)) OR ((Tanzania OR (United Republic of Tanzania) OR Zanzibar OR Tanganyika)) OR ((Togo OR (Togolese Republic)) OR Tunisia OR ((Uganda OR (Republic of Uganda)) OR ((Zambia OR (Northern Rhodesia) OR (Republic of Zambia)) OR ((Zimbabwe OR (Zimbabwe Rhodesia) OR (Southern Rhodesia) OR (Republic of Zimbabwe))
#2	Search: ((Prevalence OR Prevalences) OR (Seroprevalence OR Seroprevalences) OR (Seroepidemiologic OR Seroepidemiological))
#1	Search: Blood AND ((Donor OR Donors) OR (Donation OR Donations))

3

TABLE-S2. Characteristics of all Studies included in the systematic review and meta-analysis of TTIs (Seroprevalence of Hepatitis B Virus) among African Blood Donors

First Author and colleagues	Year of Publication	Study Design	Country	Enrolment time	Sample Size	Total participants in Study (N)	Blood donors by sex Male N(%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HBV (HBsAg) Diagnosis/Screening method	HBsAg overall positivity (N)	HBsAg overall positivity rates (%)	Risk of Bias
Siraj N. et al.	2018	Retrospective	Eritreia	2010-2016	60236	60236	39978 (66.4)	54264	5972	-	3rd Gen ELISA	1203	2.0	***Low***
Abdella S. et al.	2020	Retrospective	Ethiopia	2014-2019	554954	554954	354707 (63.9)	520658	34296	-	3rd Gen ELISA	13319	2.4	***Low***
Buseri F. et al.	2009	Prospective	Nigeria	2007-2008	1410	1410	1200 (85.1)	-	-	-	ELISA	262	18.6	***Moderate***
Okoroiwu H. et al.	2018	Both	Nigeria	2005-2016	24979	24979	24654 (98.6)	137	15487	9355	Immunochromatography	1013	4.1	***Low***
Fessehaye N. et al.	2011	Retrospective	Eritrea	2006-2009	29501	29501	-	23385	6116	6116	-	761	2.58	***Moderate***
Nzaji M. et al.	2013	Retrospective	Democratic Republic of Congo	2008	1015	1015	965 (95.1)	493	522	-	Determine™ HBSAg	17	1.6	***Moderate***
Deressa T. et al.	2018	Retrospective	Ethiopia	2014-2017	8460	8460	5644 (66.7)	-	-	-	Hepanostika HBsAg Uni-form II	102	1.2	***Moderate***
Diarra A. et al.	2009	Retrospective	Mali	2007	25543	25543	-	8094	17449	-	Monolisa AgHBS	3548	13.9	***Moderate***
Stokx J. et al.	2011	Retrospective	Mozambique	2009	750	750	-	-	-	-	RDTs	80	10.6	***Moderate***
Ankouane F. et al.	2016	Retrospective	Cameroon	2013	9024	9024	8453 (93.6)	249	8767	-	ELISA	1137	12.6	***Moderate***
Abate M. et al.	2016	Retrospective	Ethiopia	2010-2014	6827	6827	6648 (97.3)	-	-	-	ELISA	647	9.48	***Moderate***
Mohammed Y. et al.	2016	Retrospective	Ethiopia	2010-2013	4224	4224	4171 (98.7)	85	4139	-	ELISA	460	10.89	***Moderate***
Tessema B. et al.	2010	Retrospective	Ethiopia	2003-2007	6361	6361	5592 (87.9)	-	-	-	Hepanostika HBsAg Ultra	298	4.7	***Moderate***
Kubio C. et al.	2012	Retrospective	Ghana	2009	843	719	-	-	201	518	HBsAg Acon	64/843	7.5	***Moderate***

Mavenyengwa R. et al.	2014	Retrospective	Namibia	2012	24761	24761	13054 (52.7)	-	-	-	NAT	140	0.6	***High***
Keleta Y. et al.	2019	Retrospective	Eritrea	2014-2017	1939	1939	1710 (88.2)	781	1158	1158	ELISA	97	5	***Moderate***
Wongjarupong N. et al	2021	Retrospective	Burkina Faso	2009-2013	166681	166681	119437 (71.7)	-	-	-	Hepanostika HBsAg Ultra	22376	13.4	***Moderate***
Nagalo M. et al.	2011	Retrospective	Burkina Faso	2009	4520	4520	3418 (75.6)	-	-	-	Hepanostika HBsAg Ultra	676	14.96	***Low***
Peliganga L. et al.	2021	Retrospective	Angola	2005-2020	57979	57979	41414 (71.4)	-	-	-	RDTs	4928	8.5	***Low***
Kabinda J. et al.	2014	Retrospective	Democratic Republic of Congo	2011	593	568	417 (73.4)	513	4	60	2™ Determine HBsAg	27	4.8	***High***
Rerambiah L. et al.	2014	Retrospective	Gabon	2009-2011	46018	46018	31846 (69.2)	19378	21696	-	HBsAg ultra from Bio-rad	1454	3.16	***Moderate***
Yami A. et al.	2011	Retrospective	Ethiopia	2010	9204	6063	4802 (79.2)	-	-	-	ELISA	126	2.08	***Moderate***
Mahgoub S. et al.	2010	Retrospective	Sudan	2010	404	404	403 (99.7)	-	-	-	Enzygnost 5.0	48	11.8	***Moderate***
Ogbolu D, et al.	2016	Prospective	Nigeria	-	186	186	141 (75.8)	30	3	153	ELISA	27	14.52	***High***
Samje M. et al.	2021	Retrospective	Cameroon	2019	494	250	176 (70.4)	97	150	-	Immunochromatography	16	6.4	***Moderate***
Bisseye C. et al.	2018	Retrospective	Gabon	2012-2017	5706	5076	4765 (93.8)	-	5706	5706	RDTs	338	6.7	***Low***
Kengne M. et al.	2018	Prospective	Cameroon	2014	265	265	242 (91.3)	30	235	235	ELISA	31	11.7	***High***
Uneke CJ. et al.	2005	Retrospective	Nigeria	1999-2002	175	175	-	-	-	-	ELISA	25	14.3	***Moderate***
Ramos J. et al.	2016	Retrospective	Ethiopia	2007-2012	9493	2606	-	-	-	-	RDTs	129	4.95	***High***
Kabamba A. et al.	2021	Retrospective	Democratic Republic of Congo	2017-2019	1512	1512	1081 (71.5)	394	1118	-	ELISA	120	7.9	***Moderate***
Negash M. et al.	2019	Retrospective	Ethiopia	2017-2018	338	310	198 (63.8)	-	-	-	ELISA	18	5.8	***Moderate***
Jary A. et al.	2019	Retrospective	Mali	2018	8207	8059	7157 (88.8)	160	7898	-	ELISA	1191	14.78	***Moderate***

Tognon F. et al.	2020	Retrospective	Sierra Leone	2013-2016	30467	29713	22736 (76.5)	2862	23844	-	RDTs	3200	10.8	***Moderate***
Xie D. et al.	2015	Retrospective	Equatorial Guinea	2011-2013	2937	2937	2256 (76.8)	-	-	-	Immunochromatography	294	10.01	***High***
Vermeule M. et al.	2017	Retrospective	South Africa	2012-2015	3075422	397632	177729 (44.7)	-	-	-	Hepanostika Ultra	2638	6.63	***Moderate***
Kombi P. et al.	2018	Retrospective	Democratic Republic of Congo	2013-2015	5408	5408	5121 (94.7)	5259	-	-	RDTs	186	3.5	***Moderate***
Abebe M. et al.	2020	Retrospective	Ethiopia	2015-2019	17810	17810	12480 (70.1)	-	-	-	ELISA	546	3.07	***Low***
Vardas E. et al.	1999	Retrospective	Namibia	1997	1941	1941	816 (42)	-	-	-	Radioimmunoassay	192	9.89	***Low***
Boubker S. et al.	2019	Retrospective	Morocco	2013-2015	31952	31952	23177 (72.5)	-	-	-	ELISA	177	0.55	***Moderate***
Nna E. et al.	2014	Retrospective	Nigeria	2014	113	113	-	-	-	-	RDTs	13	11.5	***Moderate***
Uwingabiye J. et al.	2016	Retrospective	Morocco	2010-2012	25661	25661	24378 (95)	-	-	-	ELISA	102	0.40	***High***
Wamamba D. et al.	2017	Retrospective	Kenya	2015	3690	2046	1360 (66.5)	-	-	-	ELISA	64	3.1	***Low***
Dogbe E. et al.	2015	Retrospective	Ghana	-	300	300	-	-	-	-	3rd Gen ELISA	33	11	***Moderate***
Kwizera R. et al.	2018	Retrospective	Burundi	2016	8993	5569	2660 (48)	-	-	-	ELISA	94	1.7	***Moderate***
Mabunda N. et al.	2022	Prospective	Mozambique	2014-2015	2783	2783	2320 (83.3)	1146	1608	-	RDTs	124	4.5	***Moderate***
Fasola F. et al.	2022	Retrospective	Nigeria	2019-2020	274	274	237 (86.4)	-	-	-	RDTs	15	5.5	***Low***
Mudji J. et al.	2021	Retrospective	Democratic Republic of Congo	2016-2018	3497	3497	3232 (92.4)	492	70	2931	RDTs	117	3.4	***Low***
Choga W. et al.	2019	Prospective	Botswana	2014-2015	12575	12757	8513 (66.7)	-	-	-	ELISA	128	1.02	***Low***
Mansour W. et al.	2012	Prospective	Mauritania	2008-2009	11100	11100	-	-	-	-	ELISA	1700	15.3	***Low***
Twagirumugabe T. et al.	2017	Retrospective	Rwanda	2017	45061	45061	33875 (75)	-	-	-	ELISA	591	1.26	***Moderate***
Mba J. et al.	2018	Retrospective	Gabon	2009-2016	69862	69862	53390 (74.4)	25594	-	44268	4th ELISA	5083	7.28	***Low***
Yooda A. et al.	2019	Retrospective	Burkina Faso	2015-2017	84299	84299	59979 (71.1)	-	-	-	Architect HBsAg	5854	6.94	***Moderate***

											Qualitative II			
Allain J. et al.	2003	Retrospective	Ghana	1999-2000	13994	13994	-	6538	7456	-	EIA	25	0.18	***Low***
Nlankpe A. et al.	2021	Retrospective	Ghana	2013-2017	8605	8605	8517 (98.9)	-	-	-	DiaSpot	825	9.59	***Low***
Jacobs B. et al.	1997	Retrospective	Tanzania	1992	2333	1205	1074 (89.1)	-	-	-	ELISA	132	10.95	***Moderate***
Mohamed Z. et al.	2019	Retrospective	Tanzania	2016-2017	6402	6402	5383 (84)	763	763	5634	ELISA	262	4.1	***High***
Belyhun Y. et al.	2022	Retrospective	Ethiopia	2013	4105	1720	64 (3.7)	-	-	-	RDTs	145	8.4	***Moderate***
Hussein E. et al.	2014	Retrospective	Egypt	2006-2012	308762	308762	-	195635	-	113127	ELISA	3756	1.22	***Moderate***
Degefa B. et al.	2018	Retrospective	Ethiopia	2011-2014	10728	10728	3750 (35)	6302	4426	-	ELISA	407	3.79	***Moderate***
Koné M.C. et al.	2012	Retrospective	Mali	2007-2010	2946	2946	-	27	121	121	Test Hepa-Scan	156	5.3	***Moderate***
Mogtomo M. et al.	2009	Prospective	Cameroon	1995-2004	1513	304/1513	1171 (77.3)	80	1433	1433	Radioimmunoassay	21	6.91	***High***
Tounkara A. et al.	2009	Retrospective	Mali	2001-2002	11592	11592	10108 (87.1)	-	-	-	ELISA	1722	14.9	***High***
Diro E. et al.	2008	Retrospective	Ethiopia	2003-2004	1761	600	537 (89.5)	-	-	-	ELISA	49	8.2	***Moderate***
Ambachew H. et al.	2018	Retrospective	Ethiopia	2016	2237	2237	-	-	-	-	ELISA	106	4.7	***Low***
Motayo B. et al.	2015	Prospective	Nigeria	2013	130	130	126 (96.9)	-	130	-	EIA	13	10	***Moderate***
Seck M. et al.	2016	Prospective	Senegal	-	8219	8048	6439 (80)	-	-	-	ELISA	592	7.4	***Moderate***
Alain C. et al.	2020	Retrospective	Democratic Republic of Congo	2016-2017	360	360	301 (83.6)	-	-	-	-	38	10.6	***Low***
Lidenge S. et al.	2020	Retrospective	Tanzania	2019	504	504	431 (85.5)	-	-	-	3rd Gen ELISA	37	7.3	***Low***
Yambasu E. et al.	2018	Retrospective	Sierra Leone	2016	16865	16807	13426 (79.8)	1986	-	14760	Rapid diagnostic test (RDT)	1633	9.7	***High***
Simpore A. et al.	2014	Retrospective	Burkina Faso	2011-2012	6375	242	-	-	-	-	ELISA	24	9.9	***Moderate***
Tagny C. et al.	2016	Retrospective	Cameroon	2011-2015	1704	1596	1313 (82.2)	403	1193	1193	3rd Gen ELISA	123	7.7	***Moderate***

Ahmed E. et al.	2020	Retrospective	Sudan	2017	10897	10897	10897 (100-all men)	10897	-	-	Immunochromatography	607	5.57	***Moderate***
Onyango C. et al.	2018	Retrospective	Kenya	2015-2016	1215	1215	700 (57.6)	-	-	-	ELISA	42	3.46	***Moderate***
Bisetegen F. et al.	2016	Retrospective	Ethiopia	2015	390	390	291 (74.6)	-	-	-	ELISA	37	9.5	***High***
Ibrahim Y. et al.	2014	Retrospective	Egypt	2010-2011	17118	17118	13918 (81.3)	2101	15017	15017	HBsAg	270	2	***Moderate***
Matee M. et al.	2006	Retrospective	Tanzania	2005	1599	1599	1424 (89)	474	1125	-	3rd Gen ELISA	140	8.8	***Moderate***
Mabayoje O.V. et al.	2018	Prospective	Nigeria	2004-2005	2496	2496	1988 (79.6)	VNRBD	RD	-	ELISA	380	15.22	***Low***
Rahlenbeck I S. et al.	2015	Retrospective	Ethiopia	1994-1995	2186	549	-	VNRBD	-	-	3rd Gen ELISA	79	14.4	***Low***
Nnodu O. et al..	2003	Prospective	Nigeria	1990-2002	20574	20574	-	VNRBD	-	-	ELISA	1005	4.8	***Moderate***
Jeremiah A.Z. et al.	2011	Retrospective	Nigeria	2010-2011	266	266	244 (91.7)	VNRBD	-	-	ELISA	23	8.6	***Moderate***
Nwankwo E. et al.	2012	Retrospective	Nigeria	2008	280	280	276 (98.5)	61	62	157	HBsAg Kit	31	11.1	***High***
El-Zayadi R.A. et al.	2008	Retrospective	Egypt	2005	760	760	636 (83.6)	VNRBD	-	-	EIA	9	1.18	***Moderate***
Ndilu K.L. et al.	2016	Retrospective	Democratic Republic of Congo	2012-2013	372	372	252 (67.7)	VNRBD	-	-	-	6	1.6	***High***
Kania D. et al.	2009	Retrospective	Burkina Faso	2002	500	500	-	500	-	-	4th Gen ELISA	96	19.2	***Moderate***
Vray M. et al.	2006	Retrospective	Senegal	2003	290	175	135 (77.1)	VNRBD	-	-	EIA	10	5.71	***Moderate***
Mbanya N.D. et al.	2003	Retrospective	Cameroon	2001	264	252	197 (78.1)	VNRBD	-	-	HBsAntigen Slide ™	27	10.7	***High***
Salawu L. et al.	2011	Retrospective	Nigeria	-	495	457	443 (96.9)	VNRBD	-	-	ELISA	38	8.32	***Moderate***
Casteling A. et al.	1998	Retrospective	South Africa	-	532	510	275 (53.9)	VNRBD	-	FRD	ELISA	6/510	1.2	***Moderate***
Gudo S.E. et al.	2009	Retrospective	Mozambique	2006	2019	1865	-	VNRBD	-	-	EIA	112	7.30	***Moderate***
Bengue M.K A. et al.	2008	Retrospective	Côte d'Ivoire	2008	2866	2866	35 (1.2)	VNRBD	-	-	EIA	1	2.3	***Moderate***
Sarkodie F. et al.	2001	Retrospective	Ghana	1999	3264	3264	-	1492	1772	-	EIA	548	17	***Moderate***
Allain J. et al.	2010	Retrospective	Mali	2010	25543	25543	-	8094	17449	-	-	3548	13.9	***Low***

Allain J. et al.	2010	Retrospective	Cameroon	2010	3325	3325	-	272	3053	-	-	282	8.48	***Low***
Allain J. et al.	2010	Retrospective	Ghana	2010	11000	11000	-	6640	4360	-	-	1568	14.3	***Low***
Allain J. et al.	2010	Retrospective	Guinea	2010	10740	10740	-	1784	8956	-	-	1401	13.04	***Low***
Sarkodie F. et al.	2016	Retrospective	Ghana	2014	2455	2455	1959 (79.7)	1080	-	1133	-	156	6.4	***Low***
Allain J. et al.	2010	Retrospective	Ghana	2008	11000	11000	7901 (71.8)	6640	4360	-	Determine TM HBS Ag	1568	14.3	***Low***
Loriette M. et al.	2015	Retrospective	Cameroon	2013	2 326	2 326	-	-	-	-	Vikia HBsAg	393	16.9	***Moderate***
Malonga G.A. et al.	2022	Retrospective	Mali	2019-2020	229	229	-	-	-	-	-	22	9.6	***Moderate***
Jager H. et al.	1990	Retrospective	Democratic Republic of Congo	1989	2237	2237	2031 (90.7)	275	571	1391	ELISA	294	13.1	
Dionne-Odom J. et al.	2016	Retrospective	Cameroon	2014	3364	3364	-	3364	-	-	RDTs	229	6.8	**Low**
Aluora O.P. et al.	2020	Retrospective	Kenya	-	300	300	-	-	-	-	ELISA	7	2.3	***Moderate***
Ogbenna A.A. et al.	2022	Retrospective	Nigeria	2015-2019	45 002	45 002	-	-	-	-	ELISA	2791	6.2	***Moderate***
Adekanle O	2010	Prospective	Nigeria	2008-2009	234	234	223 (95.2)	-	-	-	ELISA	40	17.1	***Moderate***
Croce F. et al.	2007	Retrospective	Tanzania	2002	326	326	266 (81.5)	-	-	-	ELISA	17	5.2	***Moderate***
Mutimer J.D. et al.	1994	Retrospective	Nigeria	-	104	104	-	-	104	-	EIA	9	8.7	***High***
Seri B. et al.	2018	Retrospective	Côte d'Ivoire	1992-2012	422 319	422 319	312516 (73.9)	422319	-	-	ELISA	46957	11.11	***Moderate***
Ankouane F. et al.	2015	Retrospective	Cameroon	2013	9024	9024	8453 (93.6)	249	-	8767	ELISA	1137	12.6	***Moderate***
Kebede E. et al.	2020	Retrospective	Ethiopia	2018	384	384	213 (55.4)	384	-	-	ELISA	16	4.2	***Moderate***
Baha W. et al.	2013	Retrospective	Morocco	2008-2010	169605	169605	135175 (79.6)	169605	-	-	ELISA	1603	0.96	***Moderate***
Addai-Mensah O. et al.	2015	Retrospective	Ghana	2014	400	400	356 (89)	200	-	200	RDTs	27	6.8	***Moderate***
Mayaki Z. et al.	2012	Retrospective	Niger	2010	3213	3213	2574 (80.1)	2204	-	1009	EIA	495	15.4	***Moderate***
Namululi B.A. et al.	2012	Retrospective	Democratic Republic of Congo	2001-2005	7 442	6 048	2301 (38)	2898	-	382	ELISA	220/6048	3.6	***Moderate***

Shittu O.A. et al.	2014	Prospective	Nigeria	-	350	350	339 (96.8)	-	-	-	RDTs	38	10.9	***Moderate***
Mudji J. et al.	2021	Retrospective	Democratic Republic of Congo	2016-2018	3493	3493	3232 (92.5)	-	-	-	RDTs	117	3.4	***Moderate***
Japhe O.M. et al.	2011	Retrospective	Nigeria	2009	92	92	69 (67.3)	-	-	-	ELISA	18	19.6	***Moderate***
Yooda P.A. et al.	2018	Retrospective	Burkina Faso	2017	989	989	655 (66.2)	-	-	-	ELISA	72	7.28	***High***
Rerambiah L. et al..	2014	Retrospective	Gabon	2009-2011	46018	46018	31846 (69.2)	19378	21696	-	HBsAg ultra from Bio-rad	1454	3.16	***Moderate***
Rerambiah K.L. et al.	2014	Retrospective	Gabon	2014	775	775	552 (71.2)	-	-	-	Monolisa AgHBS	22	2.84	***Moderate***
Mabayoje O.V. et al.	2010	Retrospective	Nigeria	2003	297	297	137 (46)	-	-	-	Elisa	380	15.22	***High***
Quintas E.A. et al	2023	Retrospective	Angola	2011-2016	2734	2734	2467 (90)	66	-	2668	Elisa	1373	50.22	***Low***
Djoudi F. et al	2023	Retrospective	Algeria	2010-2019	140168	140168	111461 (79.52)	-	-	-	3rd Gen ELISA	143	0.10	***Low***
Singogo E. et al	2023	Retrospective	Malawi	2015-2021	204920	204920	158508 (77.4)	-	-	-	ULTRA HBV EIA	809	0.39	***Low***
Gadji M. et al	2024	Prospective	Senegal	2019-2021	5002	5002	3746 (75)	2303	-	2699	Chemiflex TM	218	4.36	***Moderate***
Jacobs G. et al	2023	Retrospective	South Africa	2012-2016	515945	515397	228059 (44.3)	515397	-	-	NAT and InnoLIA	3433	0.67	***Low***
Koura M. et al	2017	Retrospective	Burkina Faso	2009-2014	12969	12969	9797 (75.5)	-	-	-	Monolisa AgHBS	535	4.13	***Moderate***
Garba B. et al	2023	Retrospective	Nigeria	-	400	400	400 (100)	-	-	-	LabACON	46	11.50	***Low***

Enzyme-Linked Immunosorbent Assay (ELISA), *gen* generation, EIA based rapid immunochromatographic rapid kits, rapid diagnostic tests (RDTs), Hepatitis B Vírus (HBV), Hepatitis B surface antigen (HBsAg), HCV- Hepatitis C Virus InnoLIA (Innogenetics), Human Immunodeficiency Vírus (HIV), Real-time polymerase chain reaction (RT-PCR) assay; - Treponema pallidum Haemaglutination Assay (*TPHA*) test; Veneral Disease Research Laboratory (VDRL) test and**,** Plasmin Reagin Test (RPR), DiaSpot (cassette type), ACON (strips) and oneStep HIGHTOP (strips), rapid test kit (LabACON) for the qualitative detection of HBsAg.

PUBLICAÇÃO 3

Seroprevalence of Hepatitis C Virus in African Blood Donors: A Systematic Review and Meta-analysis. ***Angelina Edna Quintas***, Nelson Cuboia, Lemuel Cordeiro, António Sarmento, Luís Azevedo

Submetido à revista PLOS One em junho de 2025. Aguarda processo de revisão pelos pares e decisão final dos editores)

Seroprevalence and Temporal Trends of Hepatitis C Virus in African Blood Donors: A Systematic Review and Meta-analysis

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Abstract

Background

The hepatitis C virus (HCV) is spread worldwide, with varying prevalences in different countries. However, the synthesis of evidence on the seroprevalence among blood donors in Africa is scarce. Therefore, this study aimed to determine the seroprevalence of HCV among African blood donors and to assess temporal trends.

Methods: We conducted a systematic review and meta-analysis with data from seven electronic databases (PubMed, Web of Science, Cochrane, Scopus, HINARI, Global Index Medicus, and Clinical.Trial.gov), supplemented by manual searches. We included studies published between 1990 and March 2024, with no date of publication or language search restrictions. Data were synthesized quantitatively using a random effects meta-analysis model, and the heterogeneity was assessed using Cochrane's Q test and I^2 statistics.

Results: In total, 123 studies from 32 (59.26%) African countries met our inclusion criteria, comprising 3,446,841 blood donors tested for HCV. The pooled seroprevalence of HCV among blood donors was 2.46% (95% CI [Confidence Intervals]: 1.97 % to 3.00%; $I^2 = 100\%$, $p<0.01$). The highest prevalence was observed in the Western African region (3.33%; 95% CI 2.43 % to 4.36%; $I^2= 99.5\%$), followed by the Central region (2.69%; 95% CI: 2.11 % to 3.33%, $I^2 = 96.8\%$); Northern region (2.59%; 95% CI: 0.54 % to 6.11%, $I^2=99.9\%$); and Eastern region (1.60%; 95% CI: 1.01% to 2.31%, $I^2= 99.6\%$). The lowest prevalence was observed in Southern

Africa (0.29%; 95% CI: 0.02% to 0.75%, I^2=95.0%). We observed a decreasing temporal trend in the seroprevalence of HCV.

Conclusion: We found a very high seroprevalence of HCV among blood donors in Africa. However, the prevalence was not homogeneous across the continent, and high rates were observed in the Western, Central, and Northern African regions. Therefore, there is an urgent need to step up effective preventive measures to guarantee safety in blood transfusion in Africa.

Funding There was no specific funding for this research.

Keywords: Blood Donors; Prevalence; Hepatitis C virus; Africa; Systematic Review.

Introduction

Hepatitis C virus (HCV) is among the leading causes of post-transfusion hepatitis, cirrhosis, and liver cancer(1). In 2016, the World Health Organization (WHO) set ambitious global goals to eliminate HCV as a public health threat by 2030(2). These include a 90% reduction in new HCV infections and a 65% reduction in HCV-related mortality(2). Despite the availability of curative treatment with direct-acting antivirals, the progress toward these targets has been uneven across the regions, and Africa remains disproportionally affected(2).

Globally, it is estimated that 50 million people are infected and living with HCV, with approximately 1 million new infections occurring annually(3). Additionally, 8 million people were chronically infected in Africa as of 2022 (2, 3).

Blood transfusion, while lifesaving, has historically been a major transmission route for HCV in regions with limited screening capacity(4). HCV and other transfusion-transmitted infections (TTIs) have been significantly decreasing in the countries where routine serologic screening for blood donation has been well implemented (4-6). Globally, in low-income countries, the incidence of HCV infection among blood donors is disproportionately high, primarily due to inadequate blood screening procedures, limited access to appropriate medical equipment, and the widespread use of unsanitary injection practices among drug users (7).

Sub-Saharan Africa faces considerable challenges in achieving the WHO elimination targets due to weak healthcare infrastructure, limited availability of diagnostic testing, and the persistent burden of TTIs(2). However, there have been promising initiatives: Rwanda, for instance, has launched a national elimination program and achieved a dramatic reduction in HCV prevalence from 4% to 1.2% following the screening and treatment of over five million people(2, 6). These successes underscore the critical importance of evidence-based interventions and surveillance data to inform elimination strategies.

Numerous studies across African countries have reported a wide range of HCV seroprevalence among blood donors. As an example, a study conducted in the Democratic Republic of Congo found a prevalence of 4.8%(8) (9), one from Ghana found a prevalence of 3.57% (10), a study from Sierra Leone found a prevalence of 1.2% (11), and a study conducted in Ethiopia found a prevalence of 0.82% (12). Nevertheless, there is a notable absence of an extensive systematic review that examines and consolidates the existing data on the seroprevalence of HCV among blood donors in Africa. Therefore, this study aimed to determine the seroprevalence of HCV among African blood donors and to assess temporal trends. Given the critical role of blood transfusion safety in HCV transmission, understanding the seroprevalence of HCV among blood donors provides valuable insights into both residual transmission risks and the progress of national screening programs. This study is particularly relevant to support Africa`s path toward achieving the WHO 2030 targets by consolidating fragmented prevalence data and identifying temporal and geographical patterns that can guide targeted elimination.

Methods

Study design

This study is a systematic review and meta-analysis that compiled all available evidence on the seroprevalence of HCV among blood donors in Africa. The review was conducted and reported in accordance with PRISMA 2020 guidelines (Preferred Reporting Items for Systematic

Reviews and Meta-Analysis) and previous systematic review and meta-analysis studies on the topic (13, 14).

Registration of protocol

The study protocol was registered in PROSPERO under the number CRD42023395616. This study is part of a broader research project that assessed the prevalence of serologic markers for Hepatitis B virus (HBV), HCV, Human Immunodeficiency Virus (HIV), and Syphilis among African blood donors. Due to the extensive results, we divided the research into four separate studies, each focusing on one of the bloodborne infectious diseases: HBV, HCV, HIV, and Syphilis(15, 16).

Eligibility criteria

We included observational primary studies (cross-sectional, case-control, and cohort studies) that reported on the seroprevalence of HCV among blood donors in African countries. To be eligible, studies had to: (1) be published in any language from 1990 to March, 2024 with no date of publication or language search restrictions; (2) provide extractable data on the seroprevalence of HCV, regardless of whether it was reported as an abstract or full text; (3) include blood donors aged between 16 and 65 years. The age range of 16 to 65 years was selected based on WHO guidelines for blood donor selection(17). These guidelines recommend a minimum age of 18 years but permit donations from individuals aged 16 and 17 in countries where national regulations allow it, provided appropriate consent is given, and health criteria are met. Since national policy in some countries of our settings permits blood donation from the age of 16 with proper consent, we included this group to ensure comprehensive representation. The upper age limit of 65 years aligns with standard WHO recommendations, especially for first-time donors, and is commonly adopted across many countries to ensure donor safety. Thus, the 16-65 age range reflects international guidance and national practice.

Studies were excluded if they: a) were conducted among populations residing outside Africa; b) were case series, reviews, or editorial comments; c) contained duplicated data; d) did not provide specific data on HCV seroprevalence; and e) involved individuals already infected with HCV.

Information sources

We searched seven electronic databases: PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus, and Clinicaltrials.gov. Additionally, we manually reviewed the references of the included studies.

Search strategy

To identify relevant studies for this systematic review, we developed a comprehensive search strategy tailored to capture studies on the seroprevalence of TTIs among blood donors in African countries. We employed a combination of controlled vocabulary (e,g., Medical Subject Headings [MeSH]) and free-text terms to ensure broad retrieval across multiple electronic databases.

Boolean operators (AND, OR) were applied to combine terms related to TTIs, such as "HIV," "HBV", "HCV", and "Syphilis", with terms related to blood donation and prevalence, including "blood donor", "blood donation", "prevalence", "seroprevalence", and "Sero epidemiologic studies". A geographical filter was also applied to include all 54 African countries, using both current and historical names (e.g, "Mozambique", "Moçambique", "Gabon", "Nigeria", "South Africa") to ensure comprehensive coverage.

The final search query was constructed using a stepwise approach, combining disease-specific, epidemiological, and geographical terms to retrieve relevant articles reporting on viral and bacterial TTSs in African blood donors. The PubMed search query is provided in the Supplementary Materials I (Table S1), and equivalent customized queries were adapted for use in other electronic databases.

Selection process.

Two reviewers (AEQ and NC) independently screened and selected articles for inclusion using predefined criteria. Any discrepancies between their selections were discussed to reach a consensus, with a third reviewer (LA) resolving persistent disagreements.

Data collection process

Two reviewers, AEQ and NC, independently collected relevant data from each included study using a predesigned and mutually agreed-upon data extraction form. Any discrepancies in the extracted data were discussed, and a third reviewer, LA, resolved any persistent disagreements.

Data items

For each included study, we extracted the following information: author name, year of publication, date of participant enrollment, study design, country and African region where the study was conducted, location (unicentric or multicentric), setting (urban or rural area), total number of participants, number of blood donors who tested positive for HCV, age and sex, type of blood donors (Voluntary Non-Remunerated Donors [VNRBD], Replacement or Paid Donors [RD], and Family Donors [FD]), and the method used for HCV screening and diagnosis. This data was stored in a Microsoft Excel 2021 spreadsheet (Microsoft Corporation, Redmond, Washington, USA).

In our study, a unicentric location was defined as a study conducted at a single center or hospital, whereas a multicentric location referred to studies conducted across multiple centers or hospitals. The setting variable indicated whether the study was conducted in an urban or rural area.

Study risk of bias assessment

The risk of bias in the included studies was independently evaluated by two reviewers (AEQ and NC) using the SeroTracker-RoB tool, a decision rule-based algorithm for risk of bias assessment in seroprevalence studies(18). Any discrepancies in the quality assessment were discussed, and a third reviewer (LA) resolved persistent disagreements.

The SeroTracker-RoB tool was adapted from the Joanna Briggs Institute Checklist for Prevalence Studies. This tool consists of nine key questions to evaluate the risk of bias, each of which can be answered as "yes", "no", or "unclear. The questions are: a) Was the sample frame appropriate to address the target population? b) Were study participants recruited appropriately? c) Was the sample size adequate? d) Was the data analysis conducted with sufficient coverage of the identified sample? e) Were valid methods used to identify the condition? f) Was the condition measured in a standard, reliable way for all participants? g) Was there an appropriate adjustment for test characteristics? h) Was there an appropriate adjustment for population characteristics? i) Was the response rate adequate, and if not, was the low response rate unlikely to introduce bias? An overall risk of bias (low, moderate, high) was then determined based on automatically generated scores from the responses to these questions.

Effect measures

In this study, the effect measure for our meta-analysis was the prevalence, defined as the proportion of blood donors who tested positive for HCV.

Synthesis methods

We utilized R software version 4.3.2 (2023-10-31) with the meta package to conduct our meta-analysis of proportions (19). The DerSimonian-Laird random-effects model (20) was used to determine the pooled seroprevalence of HCV among African blood donors, with results presented alongside 95% confidence intervals. The Freeman-Tukey double arcsine

transformation (FTT) (21) was applied to estimate the proportions. To assess heterogeneity and its extent, we calculated the Cochrane Q and I^2 statistics [12].

To identify the factors contributing to heterogeneity in our study and to examine temporal trends and regional variations, we conducted meta-regression and subgroup analyses using the following variables: year of publication, African region (Western, Eastern, Central, Northern, and Southern), study location (unicentric vs. multicentric), setting (urban vs. rural), risk of bias, country of study, proportion of men, age, and type of blood donors.

Publication bias was evaluated using a funnel plot and Egger's regression test. We visualized the spatial distribution of HCV seroprevalence among African blood donors by country, with the map generated using Quantum Geographic Information System (QGIS) software (22).

Ethics

Not applicable.

Results

Four thousand four hundred and four records (4404) were identified through database and manual searching, and 500 articles were removed due to duplication. The title and abstract of the remaining 3904 articles were screened, and 3601 articles were removed as they were considered irrelevant to our study. The remaining 303 references were assessed for eligibility through the full-text examination, and 180 were excluded because they did not meet our inclusion criteria. Of these excluded: 74 did not study the prevalence of HCV among blood donors; 43 were systematic reviews; 18 did not have relevant data;14 included a population already positive for HCV; 14 focused on pregnant women; nine included children; five had no accessible full text and three involved prenatal care. The complete list of excluded studies and the corresponding reasons is provided in the supplementary materials.

Ultimately, the remaining 123 studies were considered for qualitative and quantitative synthesis, involving 3,446,841 participants. (See Fig.1). Although 117 unique publications

were identified, we treated data from the multi-county study by Tagny et al. (2009), which reported results separately from seven countries: Cameroon, Mali, Niger, Rwanda, Burkina Faso, Côte d`Ivoire and the Democratic Republic of Congo as seven distinct entries(23). This approach allowed for country-specific analysis of HCV seroprevalence among blood donors across Africa.

We cited the same multi-country study multiple times in the reference list using alphabetic suffixes (e.g., 117a-117 g), along with the corresponding country name for each entry, to ensure clarity in referencing. The full list of references for all included studies can be found in Supplementary Materials II L1.

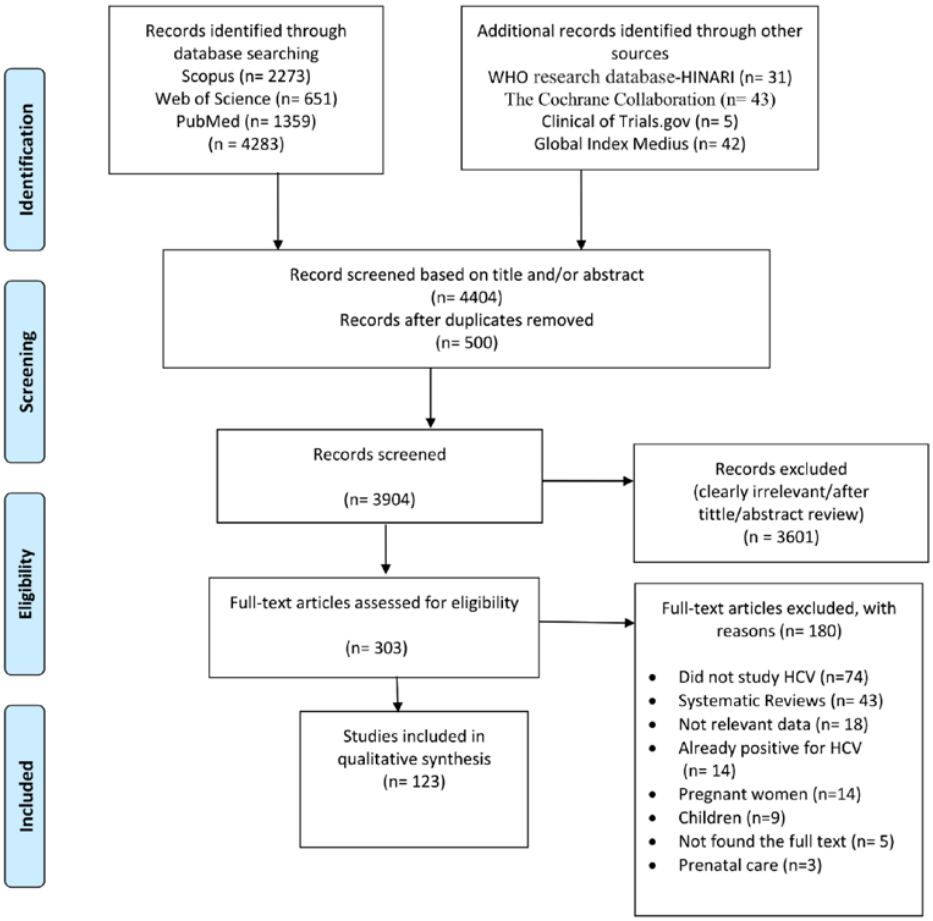


Fig. 1. PRISMA flow diagram of studies reviewed, screened, and included. HCV: Hepatitis C Virus.

Study characteristics

The characteristics of the studies included in this work are shown in Table 1. Thirty-two (59.26%) of 54 African countries are represented in the 123 studies. Most of the studies were conducted in Western Africa 53(43.09%), followed by Eastern Africa 29 (23.58%), then Central Africa 23 (18.70%), and lastly in the Northern 11 (8.94%) and Southern 7 (5.69%) African regions. The year of study publication ranged from 1990 to 2024. The majority, 84

(68.29%), were published after 2010. The median proportion of men in the included studies was 79.63 %. Most studies had a moderate risk of bias 74 (60.16%), followed by a lower risk of bias 26 (21.14%), and lastly, a high risk of bias 23 (18.70%).

Table 1. Characteristics of all studies included in the systematic review and meta-analysis of TTIs (Seroprevalence of Hepatitis C Virus) among African blood donors.

First Author and colleagues'	Year of Publication	Study Design	Country	Year of enrolment	Sample Size	Total participants in Study (N)	Blood donors by sex Male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HCV(Anti-HCV) Diagnosis/Screening methods	Anti-HCV overall positivity rates (N)	Risk of Bias
Siraj et al (24)	2018	Retrospective-cross-sectional	Eritrea	2010-2016	60236	60236	39978(66.3)	54264	5972	-	3rd Gen ELISA	442	***Low***
Abdella et al (25)	2020	Retrospective-cross-sectional	Ethiopia	2014-2019	554954	554954	354707(63.9)	520658	34296	-	3rd Gen ELISA	2220	***Low***
Buseri et al (26)	2009	Prospective-cross-sectional	Nigeria	2007-2008	1410	1410	1200 (85.1)	-	-	-	ELISA	84	***Moderate***
Okoroiwu et al (27)	2018	Retrospective-cross-sectional	Nigeria	2005-2016	24979	24979	24654 (98.6)	137	15487	9355	Immunochromatography	896	***Low***
Fessehaye et al (28)	2011	Retrospective-cross-sectional	Eritrea	2006-2009	29501	29501	-	23385	6116	6116	-	170	***Moderate***
Nzaji et al (29)	2013	Retrospective-cross-sectional	Democratic Republic of Congo	2008	1015	1015	965 (95)	493	522	-	HCV Scan	2	***Moderate***
Deressa et al (30)	2018	Retrospective-cross-sectional	Ethiopia	2014-2017	8460	8460	5644 (66.7)	-	-	-	4th Gen ELISA	27	***Moderate***
Diarra et al (31)	2009	Retrospective-cross-sectional	Mali	2007	25543	25543	-	8094	17449	-	ELISA	831	***Moderate***
Ankouane et al (32)	2016	Retrospective-cross-sectional	Cameroon	2013	9024	9024	8453 (93.6)	249	8767	-	4th Gen ELISA	289	***Moderate***
Abate et al (33)	2016	Retrospective-cross-sectional	Ethiopia	2010-2014	6827	6827	6648 (97.3)	-	-	-	4th Gen ELISA	50	***Moderate***
Mohammed et al (34)	2016	Retrospective-cross-sectional	Ethiopia	2010-2013	4224	4224	4171 (98.7)	85	4139	-	ELISA	17/487	***Moderate***
Tessema et al (35)	2010	Retrospective-cross-sectional	Ethiopia	2003-2007	6361	6361	5592 (87.9)	-	-	-	4th Gen ELISA	35	***Moderate***
Kubio et al (36)	2012	Retrospective-cross-sectional	Ghana	2009	843	719	-	-	201	518	ELISA	50/819	***Moderate***
Mavenyengwa et al (37)	2014	Retrospective-cross-sectional	Namibia	2012	24761	24761	13054 (52.7)	-	-	-	NAT	26/24761	***High***
Keleta et al (38)	2019	Retrospective-cross-sectional	Eritrea	2014-2017	1939	1939	1710 (88.1)	781	1158	1158	3rd Gen ELISA	13	***Moderate***
Wongjarupong et al (39)	2021	Retrospective-cross-sectional	Burkina Faso	2009-2013	166681	166681	119437 (71.6)	-	-	-	Hepanostika HBsAg Ultra	11535	***Moderate***
Nagalo et al (40)	2011	Retrospective-cross-sectional	Burkina Faso	2009	4520	4520	3418 (75.6)	-	-	-	Hepanostika HCV Ultra	520	***Low***
Peliganga et al (41)	2021	Retrospective-cross-sectional	Angola	2005-2020	57979	57979	41414 (71.4)	-	-	-	RDTs	1676	***Low***
Kabinda et al (42)	2014	Retrospective-cross-sectional	Democratic Republic of Congo	2011	593	568	417 (73.4)	513	4	60	2™ HCV Determine	21/544	***High***

Rerambiah et al (43)	2014	Retrospective-cross-sectional	Gabon	2009-2011	46018	46018	31846 (69.2)	19378	21696	-	ELISA	719	***Moderate***
Yami et al (44)	2011	Retrospective-cross-sectional	Ethiopia	2010	9204	6063	4802 (79.2)	-	-	-	ELISA	10	***Moderate***
Ogbolu et al (45)	2016	Prospective-cross-sectional	Nigeria	-	186	186	141 (75.8)	30	3	153	ELISA	6	***High***
Bisseye et al (46)	2018	Retrospective-cross-sectional	Gabon	2012-2017	5706	5076	4765 (93.8)	-	5706	5706	RDTs	351	***Low***
Kengne et al (47)	2018	Prospective-cross-sectional	Cameroon	2014	265	265	242 (91.3)	30	235	235	ELISA	7	***High***
Ampofo et al (48)	2002	Retrospective-cross-sectional	Ghana	1999	3131	808	762 (94.3)	30	778	-	ELISA	68	***High***
Ramos et al (49)	2016	Retrospective-cross-sectional	Ethiopia	2007-2012	9493	9493	-	-	-	-	RDTs	44/2223	***High***
Negash et al (50)	2019	Retrospective-cross-sectional	Ethiopia	2017-2018	338	310	198 (63.8)	-	-	-	ELISA	13	***Moderate***
Jary et al (51)	2019	Retrospective-cross-sectional	Mali	2018	8207	8059	7157 (88.8)	160	7898	-	ELISA	187	***Moderate***
Tognon et al (11)	2020	Retrospective-cross-sectional	Sierra Leone	2013-2016	30467	29713	22736 (71.5)	2862	23844	-	RDTs	357/29713	***Moderate***
Xie et al (52)	2015	Retrospective-cross-sectional	Equatorial Guinea	2011-2013	2937	2937	2256 (76.8)	-	-	-	Immunochromatography	109	***High***
Vermeule et al (53)	2017	Retrospective-cross-sectional	South Africa	2012-2015	3075422	397640	177729 (44.6)	-	-	-	InnoLIA	125	***Moderate***
Tigabu et al (54)	2019	Retrospective-cross-sectional	Ethiopia	2018	5983	5983	5118 (85.5)	-	-	-	Hepanostika Ultra	98	***Moderate***
Boushab et al (55)	2017	Retrospective-cross-sectional	Mauritania	2010-2015	1123	1123	182 (12.6)	-	-	-	RDTs	2	***Moderate***
Kombi et al (56)	2018	Retrospective-cross-sectional	Democratic Republic of Congo	2013-2015	5408	5408	5121 (94.6)	5259	-	-	RDTs	101	***Moderate***
Abebe et al (57)	2020	Retrospective-cross-sectional	Ethiopia	2015-2019	17810	17810	12480 (70)	-	-	-	ELISA	114	***Low***
Randriamanantany et al (58)	2012	Retrospective-cross-sectional	Madagascar	2003-2009	47636	47510	38225 (80.4)	-	-	-	RDTs	309	***Moderate***
Vardas et al (59)	1999	Retrospective-cross-sectional	Namibia	1997	1941	1941	816 (42)	-	-	-	ELISA	18	***Low***
Boubker et al (60)	2019	Retrospective-cross-sectional	Morocco	2013-2015	31952	31952	23177(72.5)	-	-	-	ELISA	6	***Moderate***
Tagny et al (61)	2014a	Retrospective-cross-sectional	Cameroon	2011	1998	1998	1614 (80.7)	-	-	-	ELISA	86	***High***
Uwingabiye et al (62)	2016	Retrospective-cross-sectional	Morocco	2010-2012	25661	25661	24378 (95)	-	-	-	4th Gen ELISA	63	***High***
Wamamba et al (63)	2017	Retrospective-cross-sectional	Kenya	2015	3690	2046	1360 (66.4)	-	-	-	ELISA	48	***Low***
Dogbe et al (64)	2015	Retrospective-cross-sectional	Ghana	-	300	300	-	-	-	-	3rd Gen ELISA	12	***moderate***
Mutyoba et al (65)	2021	Retrospective-cross-sectional	Uganda	2019-2020	1243	1243	1041 (83.7)	-	-	-	ELISA	96	***moderate***

Kwizera et al (66)	2018	Retrospective-cross-sectional	Burundi	2016	8993	5569	2660 (47.7)	-	-	-	ELISA	101	***moderate***
Mabunda et al (67)	2022	Prospective-cross-sectional	Mozambique	2014-2015	2783	2783	2320 (83.3)	1146	1608	-	Quality Rapid Anti-HCV	11	***moderate***
Mudji et al (68)	2021	Retrospective-cross-sectional	Democratic Republic of Congo	2016-2018	3497	3497	3232 (92.4)	492	70	2931	ELISA	106	***Low***
Zeba et al (69)	2014	Retrospective-cross-sectional	Burkina Faso	2011	2200	2200	62 (2.81)	-	-	-	ELISA	97	***Low***
Yooda et al (70)	2019	Retrospective-cross-sectional	Burkina Faso	2015-2017	84299	84299	59979 (71.1)	-	-	-	Architect HBsAg Qualitative II	3011	***Moderate***
Nlankpe et al (71)	2021	Retrospective-cross-sectional	Ghana	2013-2017	8605	8605	8517 (98.9)	-	-	-	DiaSpot	1094	***Low***
Candotti et al (72)	2003	Retrospective-cross-sectional	Ghana	2003	4984	4984	-	-	-	-	EIA 4.0	63	***Low***
Mohamed et al (73)	2019	Retrospective-cross-sectional	Tanzania	2016-2017	6402	6402	5383 (84.0)	763	763	5634	ELISA	62/6402	***High***
Hussein et al (74)	2014	Retrospective-cross-sectional	Egypt	2006-2012	308762	308762	-	195635	-	113127	ELISA	13414	***Moderate***
Degefa et al (75)	2018	Retrospective-cross-sectional	Ethiopia	2011-2014	10728	10728	3750 (34.9)	6302	4426	-	ELISA	143	***Moderate***
Koné et al (76)	2012	Retrospective-cross-sectional	Mali	2007-2010	2946	2946	-	27	121	121	Anti-HCV test Tri-dot	10	***Moderate***
Mogtomo et al (77)	2009	Prospective-cohort	Cameroon	1995-2004	1513	304	1171/1513 (77.3)	80	1433	1433	3rd Gen ELISA	7/284	***High***
Arthur et al (78)	1997	Retrospective-cross-sectional	Egypt	1993	3000	2644	-	-	-	-	EIA 2.0	656	***Moderate***
Diro et al (79)	2008	Retrospective-cross-sectional	Ethiopia	2003-2004	1761	600	537 (89.5)	-	-	-	ELISA	35	***Moderate***
Ambachew et al (80)	2018	Retrospective-cross-sectional	Ethiopia	2016	2237	2237	-	-	-	-	ELISA	11	***Low***
Motayo et al (81)	2015	Prospective-cross-sectional	Nigeria	2013	130	130	126 (96.9)	-	130	-	EIA	2	***Moderate***
Seck et al (82)	2016	Prospective-cross-sectional	Senegal	-	8219	8048	6439 (80)	-	-	-	ELISA	57	***Moderate***
Etard et al (83)	2003	Retrospective-cross-sectional	Senegal	2001	1081	1081	-	-	-	-	3rd Gen ELISA	18	***Moderate***
Lidenge et al (84)	2020	Retrospective-cross-sectional	Tanzania	2019	504	504	431 (85.5)	-	-	-	ELISA	16	***Low***
Yambasu et al (85)	2018	Retrospective-cross-sectional	Sierra Leone	2016	16865	16807	13426 (79.8)	1986	-	14760	RDTs	159/16802	***High***
Simpore et al (86)	2014	Retrospective-cross-sectional	Burkina Faso	2011-2012	6375	6375	-	-	-	-	4th Gen ELISA	28	***Moderate***
Ahmed et al (87)	2020	Retrospective-cross-sectional	Sudan	2017	10897	10897 all men	10897 (100)	10897	-	-	Immunochromatography	153	***Moderate***
Onyango et al (88)	2018	Retrospective-cross-sectional	Kenya	2015-2016	1215	1215	700 (57.6)	-	-	-	4th Gen ELISA	39	***Moderate***
Bisetegen et al (89)	2016	Retrospective-cross-sectional	Ethiopia	2015	390	390	291(74.6)	-	-	-	3rd Gen ELISA	33	***High***

Kwizera et al (66)	2018	Retrospective-cross-sectional	Burundi	2016	8993	5569	2660 (47.7)	-	-	-	ELISA	101	***moderate***
Mabunda et al (67)	2022	Prospective-cross-sectional	Mozambique	2014-2015	2783	2783	2320 (83.3)	1146	1608	-	Quality Rapid Anti-HCV	11	***moderate***
Mudji et al (68)	2021	Retrospective-cross-sectional	Democratic Republic of Congo	2016-2018	3497	3497	3232 (92.4)	492	70	2931	ELISA	106	***Low***
Zeba et al (69)	2014	Retrospective-cross-sectional	Burkina Faso	2011	2200	2200	62 (2.81)	-	-	-	ELISA	97	***Low***
Yooda et al (70)	2019	Retrospective-cross-sectional	Burkina Faso	2015-2017	84299	84299	59979 (71.1)	-	-	-	Architect HBsAg Qualitative II	3011	***Moderate***
Nlankpe et al (71)	2021	Retrospective-cross-sectional	Ghana	2013-2017	8605	8605	8517 (98.9)	-	-	-	DiaSpot	1094	***Low***
Candotti et al (72)	2003	Retrospective-cross-sectional	Ghana	2003	4984	4984	-	-	-	-	EIA 4.0	63	***Low***
Mohamed et al (73)	2019	Retrospective-cross-sectional	Tanzania	2016-2017	6402	6402	5383 (84.0)	763	763	5634	ELISA	62/6402	***High***
Hussein et al (74)	2014	Retrospective-cross-sectional	Egypt	2006-2012	308762	308762	-	195635	-	113127	ELISA	13414	***Moderate***
Degefa et al (75)	2018	Retrospective-cross-sectional	Ethiopia	2011-2014	10728	10728	3750 (34.9)	6302	4426	-	ELISA	143	***Moderate***
Koné et al (76)	2012	Retrospective-cross-sectional	Mali	2007-2010	2946	2946	-	27	121	121	Anti-HCV test Tri-dot	10	***Moderate***
Mogtomo et al (77)	2009	Prospective-cohort	Cameroon	1995-2004	1513	304	1171/1513 (77.3)	80	1433	1433	3rd Gen ELISA	7/284	***High***
Arthur et al (78)	1997	Retrospective-cross-sectional	Egypt	1993	3000	2644	-	-	-	-	EIA 2.0	656	***Moderate***
Diro et al (79)	2008	Retrospective-cross-sectional	Ethiopia	2003-2004	1761	600	537 (89.5)	-	-	-	ELISA	35	***Moderate***
Ambachew et al (80)	2018	Retrospective-cross-sectional	Ethiopia	2016	2237	2237	-	-	-	-	ELISA	11	***Low***
Motayo et al (81)	2015	Prospective-cross-sectional	Nigeria	2013	130	130	126 (96.9)	-	130	-	EIA	2	***Moderate***
Seck et al (82)	2016	Prospective-cross-sectional	Senegal	-	8219	8048	6439 (80)	-	-	-	ELISA	57	***Moderate***
Etard et al (83)	2003	Retrospective-cross-sectional	Senegal	2001	1081	1081	-	-	-	-	3rd Gen ELISA	18	***Moderate***
Lidenge et al (84)	2020	Retrospective-cross-sectional	Tanzania	2019	504	504	431 (85.5)	-	-	-	ELISA	16	***Low***
Yambasu et al (85)	2018	Retrospective-cross-sectional	Sierra Leone	2016	16865	16807	13426 (79.8)	1986	-	14760	RDTs	159/16802	***High***
Simpore et al (86)	2014	Retrospective-cross-sectional	Burkina Faso	2011-2012	6375	6375	-	-	-	-	4th Gen ELISA	28	***Moderate***
Ahmed et al (87)	2020	Retrospective-cross-sectional	Sudan	2017	10897	10897 all men	10897 (100)	10897	-	-	Immunochromatography	153	***Moderate***
Onyango et al (88)	2018	Retrospective-cross-sectional	Kenya	2015-2016	1215	1215	700 (57.6)	-	-	-	4th Gen ELISA	39	***Moderate***
Bisetegen et al (89)	2016	Retrospective-cross-sectional	Ethiopia	2015	390	390	291(74.6)	-	-	-	3rd Gen ELISA	33	***High***

Ibrahim et al (90)	2014	Retrospective-cross-sectional	Egypt	2010-2011	17118	17118	13918 (81.3)	2101	15017	15017	ELISA	658	***Moderate***
Matee et al (91)	2006	Retrospective-cross-sectional	Tanzania	2005	1599	1597	1424 (89.1)	474	1125	-	4th Gen ELISA	24	***Moderate***
Moukoko et al (92)	2014	Retrospective-cross-sectional	Cameroon	2012	477	477	381 (79.8)	50	-	427	4th Gen ELISA	6	***Moderate***
Mabayoje et al (93)	2018	Prospective-cross-sectional	Nigeria	2004-2005	2496	2496	1988 (79.6)	VNRBD	RD	-	ELISA	132	***Low***
Jeremiah et al (94)	2008	Retrospective-cross-sectional	Nigeria	2008	300	300	264 (88)	-	189/300	-	EIA 4.0	15	***Low***
Mboto et al (95)	2005	Retrospective-cross-sectional	Gambia	2002	513	460	509/513 (99.2)	-	-	-	ELISA	5	***Moderate***
Adewuji et al (96)	1996	Retrospective-cross-sectional	Nigeria	-	260	96	60 (62.5)	-	-	-	ELISA	5	***High***
Abdelrazik et al (97)	2018	Retrospective-cross-sectional	Egypt	2017	1850	1850	-	VNRBD	-	-	ELISA	143	***Moderate***
Jeremiah et al (98)	2011	Retrospective-cross-sectional	Nigeria	2010-2011	266	266	244 (91.7)	VNRBD	-	-	ELISA	4	***Moderate***
Nwankwo et al (99)	2012	Retrospective-cross-sectional	Nigeria	2008	280	280	276 (98.5)	61	62	157	HBsAg Kit	5	***High***
El-Zayadi et al (100)	2008	Retrospective-cross-sectional	Egypt	2005	760	760	636 (83.6)	VNRBD	-	-	ELISA	38	***Moderate***
Ndilu et al (101)	2016	Retrospective-cross-sectional	Democratic Republic of Congo	2012-2013	372	372	252 (67.7)	VNRBD	-	-	-	4	***High***
Kania et al (102)	2009	Retrospective-cross-sectional	Burkina Faso	2002	500	500	-	500	-	-	4th Gen ELISA	26	***Moderate***
Mbanya et al (103)	2003	Retrospective-cross-sectional	Cameroon	2001	264	252	197 (78.1)	VNRBD	-	-	INNOLIA™	12	***High***
Casteling et al (104)	1998	Retrospective-cross-sectional	South Africa	-	532	532	275 (51.6)	VNRBD	-	FRD	ELISA	4/511	***Moderate***
Amine et al (105)	2010	Retrospective-cohort	Morocco	2002-2005	38400	3600	-	VNRBD	-	-	3rd Gen ELISA	12	***Moderate***
Bengue et al (106)	2008	Retrospective-cross-sectional	Côte d'Ivoire	2008	2866	2866	35 (1.2)	VNRBD	-	-	EIA	43	***Moderate***
Mbanya et al (103)	2010	Retrospective-cross-sectional	Guinea Conakry	2008	21130	10740	-	1784	8956	-	Monalisa anti-HCV-EIA	34	***Moderate***
Ayolabi et al (107)	2006	Retrospective-cross-sectional	Nigeria	2004	167	167	160 (95.8)	-	RD	-	3rd Gen ELISA	14	***High***
Maida et al (108)	2000	Retrospective-cross-sectional	Malawi	1996	100	100	-	-	-	-	3rd EIA+ELISA Kit	4	***Moderate***
Sarkodie et al (109)	2001	Retrospective-cross-sectional	Ghana	1999	3264	3264	-	1492	1772	-	EIA	56	***Moderate***
Allain et al (110)	2010	Retrospective-cross-sectional	Mali	2010	25543	25543	-	8094	17449	-	-	831	***Low***
Sarkodie et al (111)	2016	Retrospective-cross-sectional	Ghana	2014	2455	2455	1959 (79.7)	1080	-	1133	-	22/2455	***Low***
Allain et al (112)	2010	Retrospective-cross-sectional	Ghana	2008	11000	11000	7901 (71.8)	6640	4360	-	EIA	24	***Low***

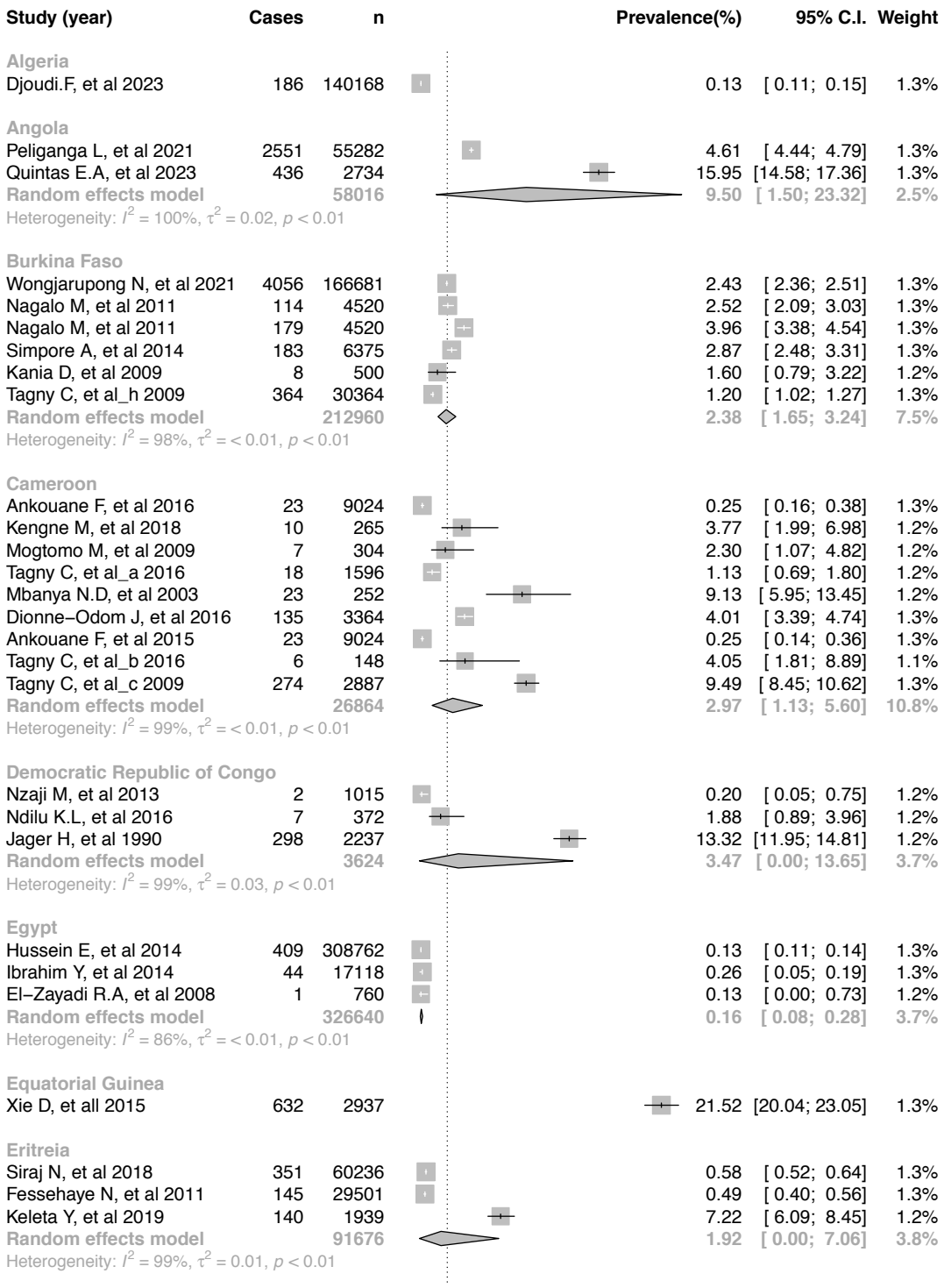
Loriette et al (113)	2015	Retrospective-cohort	Cameroon	2013	2 326	2 326	_	-	-	-	Immunocomb HCV	24/1032	***Moderate***
Malonga et al (114)	2022	Retrospective-cross-sectional	Mali	2019-2020	229	229	_	-	-	-	_	6	***Moderate***
Dionne-Odom et al (115)	2016	Retrospective-cross-sectional	Cameroon	2014	3364	3364	_	3364	-	-	3rd generation EIA	57	**Low**
Ogbenna et al (116)	2022	Retrospective-cohort	Nigeria	2015-2019	45 002	45 002	_	-	-	-	ELISA	1014	***Moderate***
Rerambiah et al (43)	2014	Retrospective-cross-sectional	Gabon	NA	775	775	552 (71.2)	-	-	-	Monolisa HCV ag Ultra	10	***Moderate***
Croce et al (117)	2007	Retrospective-cross-sectional	Tanzania	2002	326	326	266 (81.5)	-	-	-	ELISA	18	***Moderate***
Schoub et al.(118)	1992	Retrospective-cohort	South Africa	1991	117	117	_	-	-	-	ELISA	1	***High***
Mutimer et al.(119)	1994	Retrospective-cross-sectional	Nigeria	NA	104	104	_	_	104	-	ELISA	(6)28	***High***
Ellis et al (120)	1990	Retrospective-cohort	South Africa	1986	1498	1498	-	-	-	-	ELISA	13	***High***
Ankouane et al (32)	2015	Retrospective-cross-sectional	Cameroon	2013	9024	9024	8453 (93.6)	249	-	8767	ELISA	289	***Moderate***
Baha et al (121)	2013	Retrospective-cross-sectional	Morocco	2008-2010	169605	169605	135175 (79.6)	169605	-	-	Ag/Ab HCV Combination Assay	1057	***Moderate***
Addai-Mensah et al (122)	2015	Retrospective-cross-sectional	Ghana	2014	400	400	356 (89)	200	-	200	RDTs	5	***Moderate***
Mayaki et al (123)	2012	Retrospective-cross-sectional	Niger	2010	3213	3213	2574 (80)	2204	-	1009	EIA	38	***Moderate***
Mudji J. et al (124)	2021	Retrospective-cross-sectional	Democratic Republic of Congo	2016-2018	3493	3493	3232 (92.5)	-	-	-	RDTs	106	***Moderate***
Ruggieri et al (125)	1996	Retrospective-cross-sectional	Guinea Conakry	1993	228	228	-	-	-	-	ELISA	10	***Moderate***
Yooda et al (70)	2018	Retrospective-cross-sectional	Burkina Faso	2017	989	989	655 (66.2)	-	-	-	ELISA	27	***High***
Layden et al (126)	2014	Retrospective-cross-sectional	Ghana	2013-2014	363	363	301 (82.9)	-	-	-	Real-time polymerase chain reaction (RT-PCR) assay	87	***Moderate***
Mabayoje et al (93)	2010	Retrospective-cohort	Nigeria	-	297	297	137 (46.1)	-	-	-	ELISA	14	***High***
Quintas et al (127)	2023	Retrospective-cross-sectional	Angola	2011-2016	2734	2734	2467 (90.2)	66	-	2668	ELISA	140	***Low***
Djoudi.et al (128)	2023	Retrospective-cross-sectional	Algeria	2010-2019	140168	140168	111461(79.5)	VNRBD	-	-	3rd generation EIA	117	***Low***
Singogo et al (129)	2023	Retrospective-cohort	Malawi	2015-2021	204920	204920	158508(74.2)	VNRBD	-	-	Monalisa anti-HCV	4918	***Low***
Gadji et al (130)	2024	Prospective-cross-sectional	Senegal	-	5002	5002	3746 (74.8)	2303	-	2699	Chemiflex™	30	***Moderate***
Jacobs et al (131)	2023	Retrospective-cross-sectional	South Africa	2012-2016	515397	515397	228059(44.2)	-	-	-	ID-NAT	169	***Low***

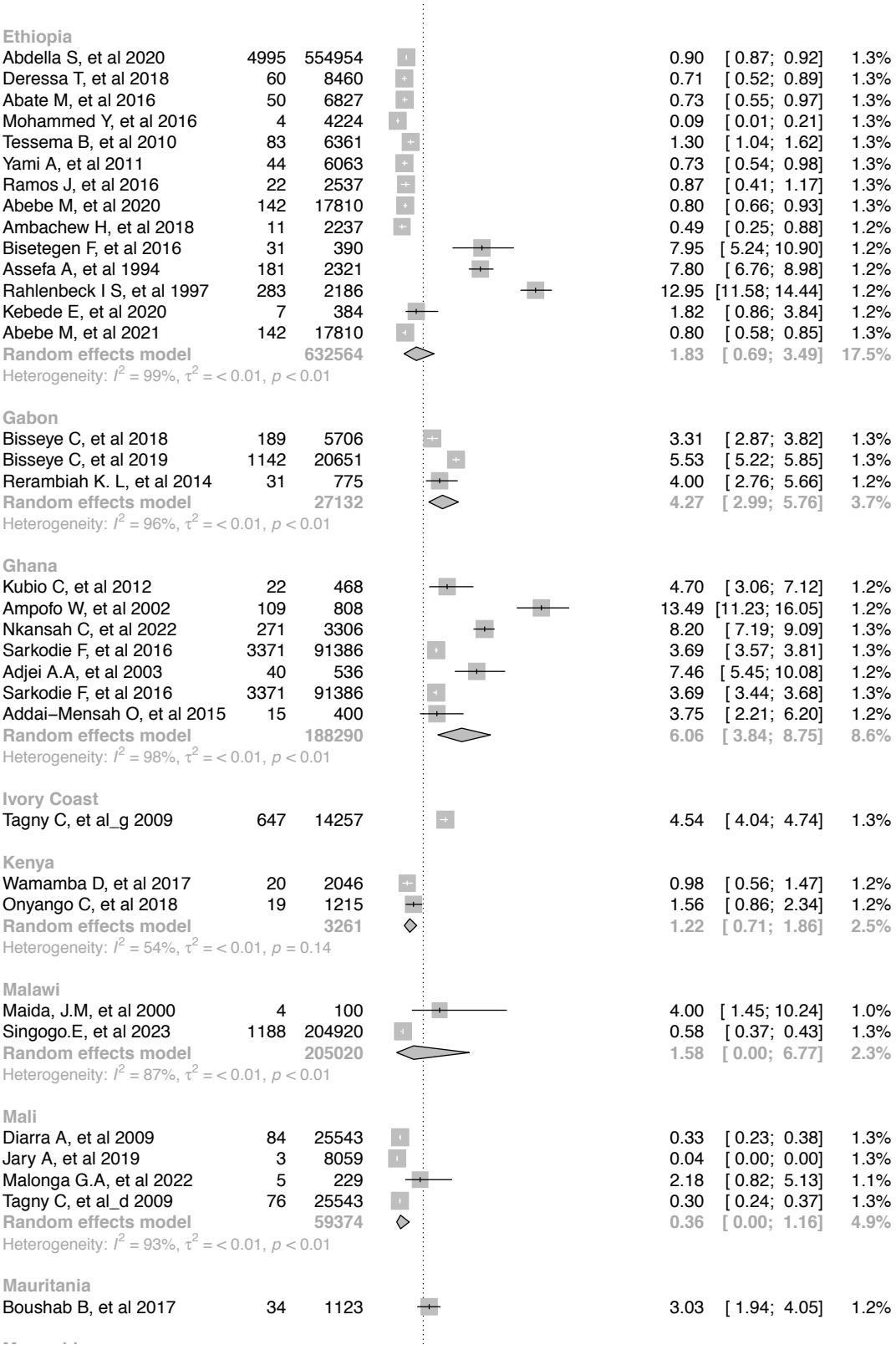
Koura et al (132)	2017	Retrospective-cohort	Burkina Faso	2009-2014	12969	12969	9797 (75.5)	VNRBD	-	-	ELISA	641	***Moderate***
Garba.et al (133)	2023	Retrospective-cross-sectional	Nigeria	-	400	400	400 (100)	VNRBD	-	-	Rapid test kit	12	***Low***
Isa et al (134)	2010	Retrospective-cross-sectional	Nigeria	2000-2003	4731	4731	4731 (100)	VNRBD	-	-	ELISA	86	***Moderate***
Zeba.et al (69)	2014	Prospective-cross-sectional	Burkina Faso	1998-2011	2200	2200	-	VNRBD	-	-	4th ELISA	97	***Low***
Tagny et al (23)	2009b	Retrospective-cross-sectional	Cameroon	-	2887	2887	-	VNRBD	-	FRD	ELISA	112	***Moderate***
Tagny et al (23)	2009c	Retrospective-cross-sectional	Mali	-	25543	25543	-	VNRBD	-	FRD	ELISA	830	***Moderate***
Tagny et al (23)	2009d	Retrospective-cross-sectional	Niger	-	2962	2962	-	VNRBD	-	FRD	ELISA	42	***Moderate***
Tagny et al (23)	2009e	Retrospective-cross-sectional	Rwanda	-	37000	37000	-	VNRBD	-	FRD	ELISA	1158	***Moderate***
Tagny et al (23)	2009f	Retrospective-cross-sectional	Côte d'Ivoire	-	14257	14257	-	VNRBD	-	FRD	ELISA	995	***Moderate***
Tagny et al (23)	2009g	Retrospective-cross-sectional	Burkina Faso	-	30364	30364	-	VNRBD	-	FRD	ELISA	971	***Moderate***
Tagny et al (23)	2009h	Retrospective-cross-sectional	Democratic Republic of Congo	-	480	480		VNRBD	-	FRD	ELISA	10	***Moderate***

Enzyme-Linked Immunosorbent Assay (ELISA), *gen* generation, EIA-based rapid immunochromatographic rapid kits, Rapid diagnostic tests (RDTs), Transfusion Transmitted Infections (TTIs), Hepatitis B surface antigen (HBsAg) of Hepatitis B vírus (HBV), Hepatitis C virus (HCV), Innogenetics (InnoLIA), Human Immunodeficiency Virus (HIV), Real-time polymerase chain reaction (RT-PCR) assay, Treponema pallidum Hemagglutination Assay (*TPHA*) test, Venereal Disease Research Laboratory (VDRL) test, RPR Plasmin Reagin Test, DiaSpot (cassette type), ACON (strips) and oneStep HIGHTOP (strips), individual donation nucleic acid amplification testing (ID-NAT).

Seroprevalence of Hepatitis C Virus

We found that the pooled seroprevalence of HCV among blood donors in Africa was 2.46% (95% CI [Confidence interval]: 1.97 % to 3.00%; I^2 = 100%, p<0.01) (See the forest plot in Fig. 2).


Study (year) Cases n Prevalence(%) 95% C.I. Weight
Algeria
Djoudi.F, et al 2023 186 140168 0.13 [0.11; 0.15] 1.3%
Angola
Peliganga L, et al 2021 2551 55282 4.61 [4.44; 4.79] 1.3%
Quintas E.A, et al 2023 436 2734 15.95 [14.58; 17.36] 1.3%
Random effects model 58016 9.50 [1.50; 23.32] 2.5%
Heterogeneity: I^2 = 100%, τ^2 = 0.02, p < 0.01
Burkina Faso
Wongjarupong N, et al 2021 4056 166681 2.43 [2.36; 2.51] 1.3%
Nagalo M, et al 2011 114 4520 2.52 [2.09; 3.03] 1.3%
Nagalo M, et al 2011 179 4520 3.96 [3.38; 4.54] 1.3%
Simpore A, et al 2014 183 6375 2.87 [2.48; 3.31] 1.3%
Kania D, et al 2009 8 500 1.60 [0.79; 3.22] 1.2%
Tagny C, et al_h 2009 364 30364 1.20 [1.02; 1.27] 1.3%
Random effects model 212960 2.38 [1.65; 3.24] 7.5%
Heterogeneity: I^2 = 98%, τ^2 = < 0.01, p < 0.01
Cameroon
Ankouane F, et al 2016 23 9024 0.25 [0.16; 0.38] 1.3%
Kengne M, et al 2018 10 265 3.77 [1.99; 6.98] 1.2%
Mogtomo M, et al 2009 7 304 2.30 [1.07; 4.82] 1.2%
Tagny C, et al_a 2016 18 1596 1.13 [0.69; 1.80] 1.2%
Mbanya N.D, et al 2003 23 252 9.13 [5.95; 13.45] 1.2%
Dionne−Odom J, et al 2016 135 3364 4.01 [3.39; 4.74] 1.3%
Ankouane F, et al 2015 23 9024 0.25 [0.14; 0.36] 1.3%
Tagny C, et al_b 2016 6 148 4.05 [1.81; 8.89] 1.1%
Tagny C, et al_c 2009 274 2887 9.49 [8.45; 10.62] 1.3%
Random effects model 26864 2.97 [1.13; 5.60] 10.8%
Heterogeneity: I^2 = 99%, τ^2 = < 0.01, p < 0.01
Democratic Republic of Congo
Nzaji M, et al 2013 2 1015 0.20 [0.05; 0.75] 1.2%
Ndilu K.L, et al 2016 7 372 1.88 [0.89; 3.96] 1.2%
Jager H, et al 1990 298 2237 13.32 [11.95; 14.81] 1.2%
Random effects model 3624 3.47 [0.00; 13.65] 3.7%
Heterogeneity: I^2 = 99%, τ^2 = 0.03, p < 0.01
Egypt
Hussein E, et al 2014 409 308762 0.13 [0.11; 0.14] 1.3%
Ibrahim Y, et al 2014 44 17118 0.26 [0.05; 0.19] 1.3%
El−Zayadi R.A, et al 2008 1 760 0.13 [0.00; 0.73] 1.2%
Random effects model 326640 0.16 [0.08; 0.28] 3.7%
Heterogeneity: I^2 = 86%, τ^2 = < 0.01, p < 0.01
Equatorial Guinea
Xie D, et all 2015 632 2937 21.52 [20.04; 23.05] 1.3%
Eritreia
Siraj N, et al 2018 351 60236 0.58 [0.52; 0.64] 1.3%
Fessehaye N, et al 2011 145 29501 0.49 [0.40; 0.56] 1.3%
Keleta Y, et al 2019 140 1939 7.22 [6.09; 8.45] 1.2%
Random effects model 91676 1.92 [0.00; 7.06] 3.8%
Heterogeneity: I^2 = 99%, τ^2 = 0.01, p < 0.01


Ethiopia
Abdella S, et al 2020 4995 554954 0.90 [0.87; 0.92] 1.3%
Deressa T, et al 2018 60 8460 0.71 [0.52; 0.89] 1.3%
Abate M, et al 2016 50 6827 0.73 [0.55; 0.97] 1.3%
Mohammed Y, et al 2016 4 4224 0.09 [0.01; 0.21] 1.3%
Tessema B, et al 2010 83 6361 1.30 [1.04; 1.62] 1.3%
Yami A, et al 2011 44 6063 0.73 [0.54; 0.98] 1.3%
Ramos J, et al 2016 22 2537 0.87 [0.41; 1.17] 1.3%
Abebe M, et al 2020 142 17810 0.80 [0.66; 0.93] 1.3%
Ambachew H, et al 2018 11 2237 0.49 [0.25; 0.88] 1.2%
Bisetegen F, et al 2016 31 390 7.95 [5.24; 10.90] 1.2%
Assefa A, et al 1994 181 2321 7.80 [6.76; 8.98] 1.2%
Rahlenbeck I S, et al 1997 283 2186 12.95 [11.58; 14.44] 1.2%
Kebede E, et al 2020 7 384 1.82 [0.86; 3.84] 1.2%
Abebe M, et al 2021 142 17810 0.80 [0.58; 0.85] 1.3%
Random effects model 632564 1.83 [0.69; 3.49] 17.5%
Heterogeneity: I^2 = 99%, τ^2 = < 0.01, p < 0.01
Gabon
Bisseye C, et al 2018 189 5706 3.31 [2.87; 3.82] 1.3%
Bisseye C, et al 2019 1142 20651 5.53 [5.22; 5.85] 1.3%
Rerambiah K. L, et al 2014 31 775 4.00 [2.76; 5.66] 1.2%
Random effects model 27132 4.27 [2.99; 5.76] 3.7%
Heterogeneity: I^2 = 96%, τ^2 = < 0.01, p < 0.01
Ghana
Kubio C, et al 2012 22 468 4.70 [3.06; 7.12] 1.2%
Ampofo W, et al 2002 109 808 13.49 [11.23; 16.05] 1.2%
Nkansah C, et al 2022 271 3306 8.20 [7.19; 9.09] 1.3%
Sarkodie F, et al 2016 3371 91386 3.69 [3.57; 3.81] 1.3%
Adjei A.A, et al 2003 40 536 7.46 [5.45; 10.08] 1.2%
Sarkodie F, et al 2016 3371 91386 3.69 [3.44; 3.68] 1.3%
Addai–Mensah O, et al 2015 15 400 3.75 [2.21; 6.20] 1.2%
Random effects model 188290 6.06 [3.84; 8.75] 8.6%
Heterogeneity: I^2 = 98%, τ^2 = < 0.01, p < 0.01
Ivory Coast
Tagny C, et al_g 2009 647 14257 4.54 [4.04; 4.74] 1.3%
Kenya
Wamamba D, et al 2017 20 2046 0.98 [0.56; 1.47] 1.2%
Onyango C, et al 2018 19 1215 1.56 [0.86; 2.34] 1.2%
Random effects model 3261 1.22 [0.71; 1.86] 2.5%
Heterogeneity: I^2 = 54%, τ^2 = < 0.01, p = 0.14
Malawi
Maida, J.M, et al 2000 4 100 4.00 [1.45; 10.24] 1.0%
Singogo.E, et al 2023 1188 204920 0.58 [0.37; 0.43] 1.3%
Random effects model 205020 1.58 [0.00; 6.77] 2.3%
Heterogeneity: I^2 = 87%, τ^2 = < 0.01, p < 0.01
Mali
Diarra A, et al 2009 84 25543 0.33 [0.23; 0.38] 1.3%
Jary A, et al 2019 3 8059 0.04 [0.00; 0.00] 1.3%
Malonga G.A, et al 2022 5 229 2.18 [0.82; 5.13] 1.1%
Tagny C, et al_d 2009 76 25543 0.30 [0.24; 0.37] 1.3%
Random effects model 59374 0.36 [0.00; 1.16] 4.9%
Heterogeneity: I^2 = 93%, τ^2 = < 0.01, p < 0.01
Mauritania
Boushab B, et al 2017 34 1123 3.03 [1.94; 4.05] 1.2%

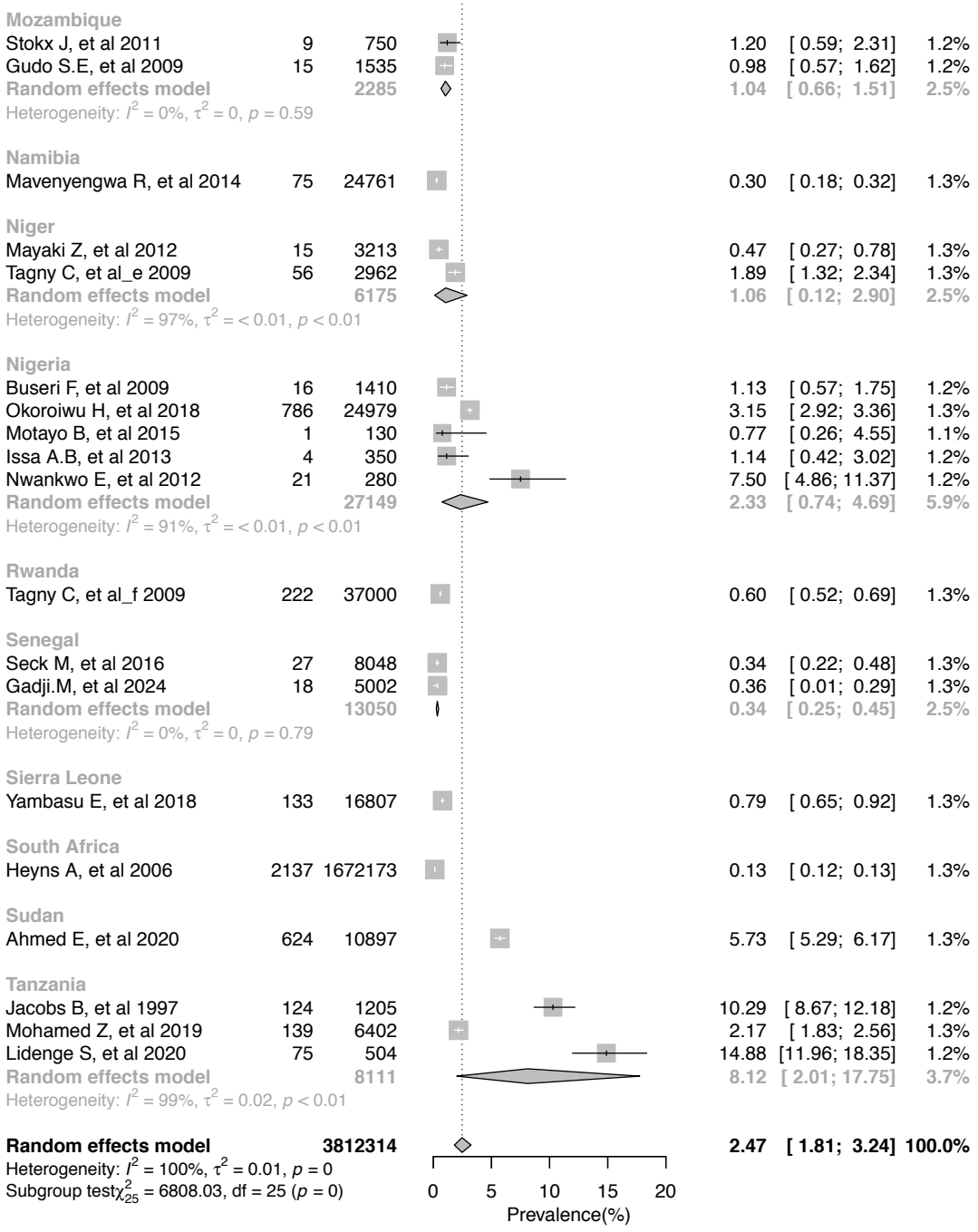


Fig. 2: Forest plot of the pooled seroprevalence of Hepatitis C Virus in African donors by country. Random-effect model: subgroup analysis by region. ES-estimated prevalence of HCV.

In subgroup analysis, we found statistically significant differences in the pooled seroprevalence of HCV among blood donors in Africa according to the study country (p-value <0.01) and African region (p-value < 0.01). (Fig. 2, 3, and Table 2).

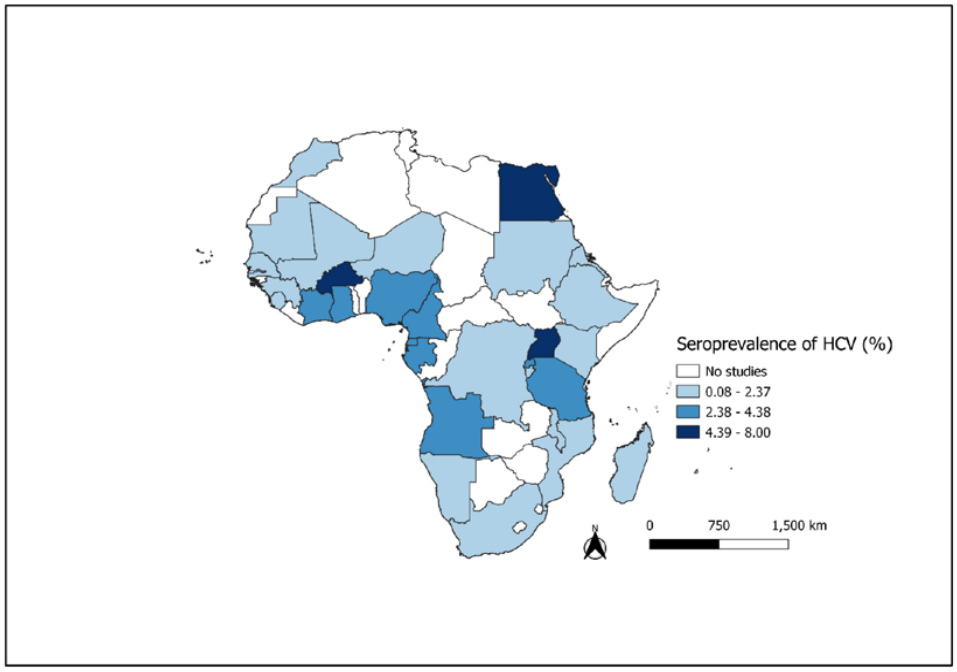


Fig. 3: Map of the seroprevalence of HCV among blood donors in Africa.

The seroprevalence of HCV varied across African regions, with the highest prevalence observed in Western Africa (3.33%; 95% CI: 2.43% - 4.36%; $I^2 = 99.5\%$), followed by Central Africa (2.69%; 95% CI: 2.11% - 3.33%; $I^2 = 96.8\%$) and Northern Africa (2.59%; 95% CI: 0.54% - 6.11%; $I^2 = 99.9\%$). Eastern Africa reported a lower prevalence of 1.60% (95% CI:

1.01% - 2.31%; I^2 = 99.6%), while Southern Africa showed the lowest prevalence at 0.29% (95% CI: 0.02% - 0.75%; I^2 = 95.0%). (See Fig. 3 and Table 2).

Table 2: Sub-group analysis of the pooled prevalence of HCV estimation in African blood donors by region (1990-2024).

Moderator variables	Category	N° of studies	Prevalence % (95% CI)	I^2(%)	P-value
Africa region	Western	53	3.33 (2.43; 4.36)	99.5	<0.01
	Eastern	29	1.60 (1.01; 2.31)	99.6	
	Central	23	2.69 (2.11; 3.33)	96.8	
	Northern	11	3.60 (0.54; 6.11)	99.9	
	Southern	7	0.29 (0.02; 0.75)	95.0	
Year of publication	1990-2000	9	4.80 (0.95; 11.15)	99.3	0.18
	2001-2010	30	2.87 (2.09; 3.77)	98.9	
	2011-2024	84	2.14 (1.63; 2.72)	99.9	

I^2= Heterogeneity; P-value: significance test of subgroup differences

We found high heterogeneity among pooled studies (Cochran Q test *p*-value < 0.01 and I^2 = 100%). In the meta-regression analysis, we observed that the heterogeneity was moderated by the country where the study was performed (*p*-value <0.01), year of study publication (*p*-value = 0.01), and the African region (*p*-value <0.01) (see Table 3). Additionally, we found a decreasing temporal trend in the seroprevalence of HCV (see Figure 4 and Tables 2 and 3).

Table 3: Moderators of heterogeneity on the seroprevalence of HCV in blood donors in Africa.

Variables	Moderators test p-value	R^2 (%)
Year of study publication	0.01	3.41
African regions	<0.01	9.40
Country	<0.01	27.45
Risk of bias	0.58	0.00
Location	0.78	0.00
Setting	0.94	0.00
Type of Bloody donors	0.53	0.00

R^2: The amount of heterogeneity explained by the moderator variable

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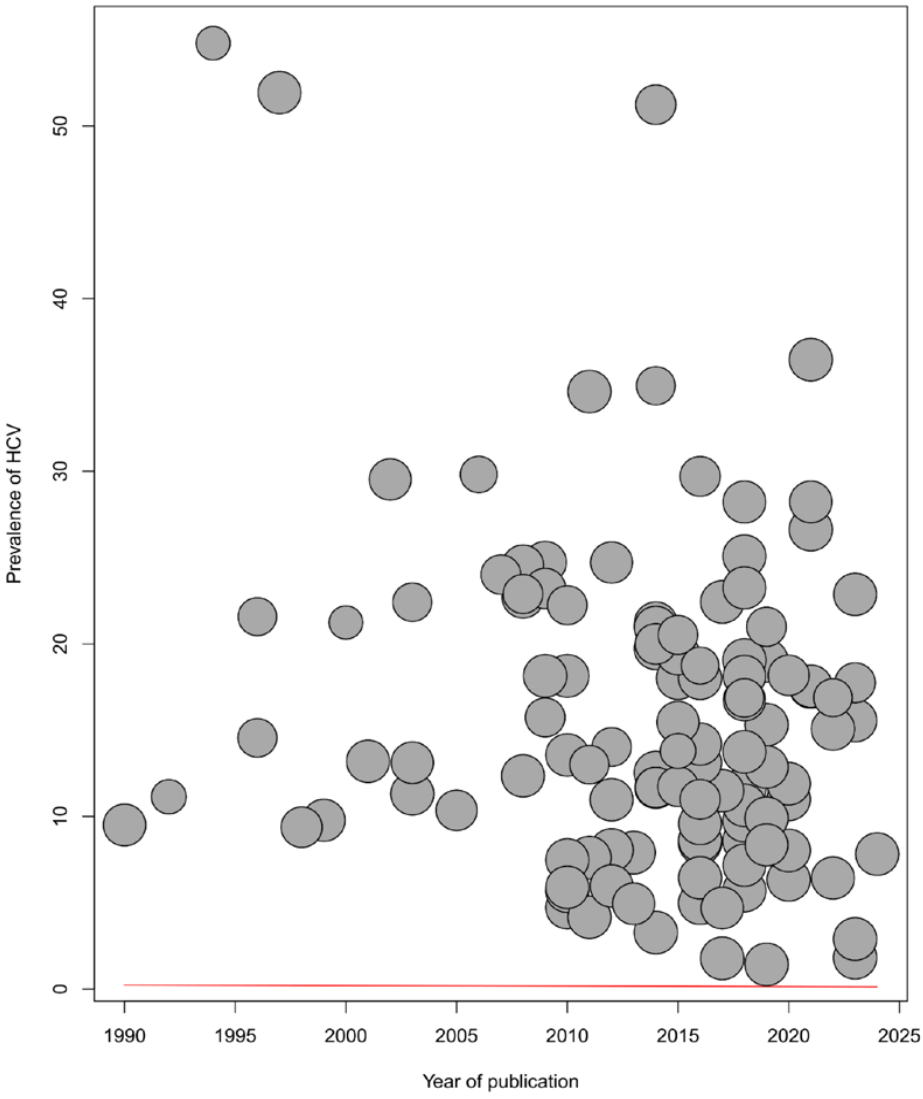
312



313

Fig. 4: Bubble plot meta-regression of seroprevalence of HCV among blood donors in Africa and year of publication.

We did not find a statistically significant variation in the seroprevalence of HCV by the risk of bias (p-value = 0.58), study location (p-value = 0.78), setting (p-value= 0.94), or type of blood donor (p-value = 0.53) (see Fig. 3, and Table 2 and 3).

The funnel plot **was asymmetrical**, and the regression Egger test was statistically significant (p-value <0.01). This may indicate a risk of potential publication bias, but there are in this case several other reasons that may explain the asymmetry observed in the funnel plot, namely, heterogeneity and its moderators (See Fig. 5).

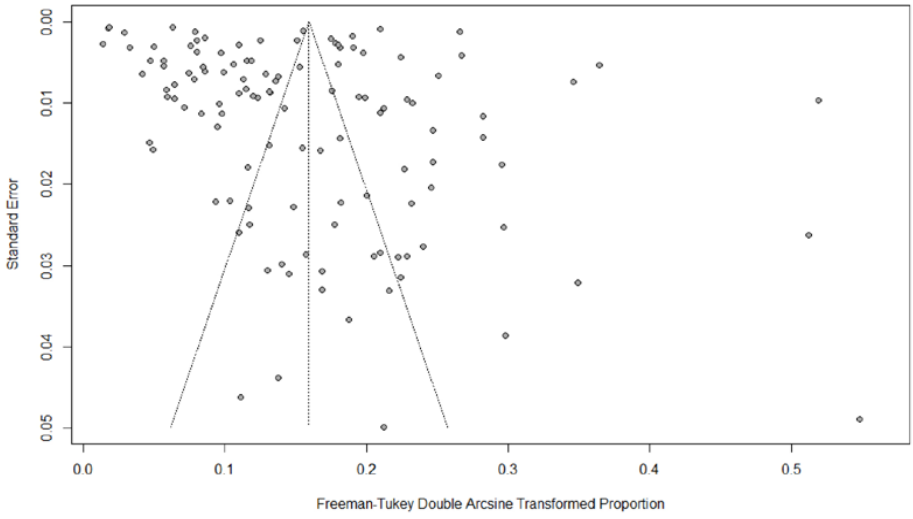


Fig. 5: Funnel plot assessing publication bias in studies on HCV seroprevalence among African blood donors (1990-2024).

Discussion: Our study reveals a seroprevalence of HCV among African blood donors of 2.46%, with significant variation across the continent. Notably, high prevalence rates were observed in Western, Northern, and Central African regions, while lower rates were found in

Eastern and Southern Africa. Additionally, we identified a downward temporal trend in the prevalence of HCV among African donors.

When compared with global data, the prevalence of HCV among blood donors in our study exceeded rates reported in other systematic reviews and meta-analyses conducted in Europe and other regions. For example, studies in Europe reported prevalence rates of HCV among blood donors ranging from 0.03% in Greece to 0.09% in Italy (135). Similar low prevalence rates were observed in Vietnam (0.18%) (136), Iran (0.5%) (8), and among Mexican blood donors living in the United States (0.0% to 2.05%) (137). In India, the prevalence was reported to be 0.44% (138), while in China, a higher prevalence of 8.68% was documented[16].

Several factors may explain these differences, including the underlying endemicity of HCV in the general population, disparity in access to healthcare and public health initiatives, and differences in study population characteristics (139),(140). Cultural and behavioral factors related to TTIs may also play a role(139), (140). Therefore, these findings reinforce the need for regionally tailored interventions that reflect local epidemiological contexts.

Our findings of a temporal decline in HCV seroprevalence mirror findings from China (141). This downward trend has been attributed to improved healthcare access, implementation of effective public health initiatives and the widespread use of sensitive diagnostic tools (142). Moreover, increased public awareness and education on HCV transmission and prevention have encouraged safer practices, including a significant reduction in needle-sharing among drug users and improved infection control in healthcare settings. The availability of highly effective antiviral therapies that can cure HCV has also been instrumental in lowering prevalence rates(143) (144).

Recent studies highlight both progress and persistent gaps in Africa`s path toward achieving the WHO 2030 HCV elimination goals. Nyamu et al. (2024) noted that despite increased awareness of WHO`s elimination targets, many African countries face critical barriers,

including limited diagnostic tools, low treatment coverage, and weak data reporting systems. In Zimbabwe, Mabaya et al. (2024) found persistent gaps in access to HCV care and treatment linkage among blood donors(145).

Nonetheless, promising country-level initiatives have emerged. Rwanda has leveraged its national HIV infrastructure to deliver widespread HCV screening and treatment(2). As of 2021, more than 5 million individuals were screened and over 51,000 treated, achieving a cure rate of 92% and a drop in prevalence from 4% to 1.2%. In Nigeria`s Nasarawa State, where HCV prevalence exceeds 13%, a pilot program integrated HCV and TB testing using a point-of-care approach demonstrates a scalable co-testing model in high-burden areas(2).

Building on these examples, Puerto-Meredith et al. (2023) conducted a systematic review of TTIs in Southern Africa(146). Their findings confirm that HCV remains a significant concern in the region, with only a few countries having accredited national transfusion services capable of supporting WHO-aligned screening and hemovigilance systems(146). Strengthening this infrastructure is essential to achieving the WHO`s 2030 elimination of HCV goals.

The introduction of rapid point-of-care RNA testing offers a promising solution to close diagnostic gaps and reduce loss to follow-up by enabling timely confirmation of active HCV infection(2, 147). However, these technologies are not widely available across the continent (2). Their broader adoption, simplified diagnostic algorithms, and service decentralization are critical to accelerate progress, especially in underserved and high-prevalent regions.

Cwinyaai et al. (2024) and Mangala et. al. (2024) further documented gaps in molecular diagnostic capacity and called for urgent investment in integrated surveillance and laboratory systems for HCV RNA testing across African countries(14, 148). These findings support beyond antibody screening toward RNA-confirmed diagnoses in blood safety programs.

In line with the WHO 2030 elimination goals, reflex HCV RNA testing should complement antibody screening among blood donors to confirm active infection(2, 6). This approach

ensures timely diagnosis and linkage to care, especially in resource-limited settings where follow-up is often missed(2, 6). Early identification of viremic donors enhances patient safety and supports national elimination strategies to reduce new infections by 90% and HCV-related mortality(2, 6).

Limitations

Our systematic review has some limitations. The pooled seroprevalence of HCV among blood donors cannot be generalized across Africa, as 22 countries (40.74%) lacked relevant studies. Furthermore, countries in Africa's Western, Eastern, and Central regions were disproportionally overrepresented, while those in Northern and Southern Africa were underrepresented. Additionally, we encountered significant heterogeneity among the included studies (I^2=100%). Therefore, further research is necessary, particularly in the underrepresented regions, to provide a comprehensive overview of HCV seroprevalence among African blood donors.

Another limitation is that most included studies assessed HCV infection using serological tests (anti-HCV antibodies) rather than confirmatory HCV RNA testing. While serology is widely used in blood donor screening, it may overestimate active infection due to the persistence of antibodies even after viral clearance, and it cannot distinguish between current and resolved infections(147). This anti-HCV antibody test limits the ability to accurately determine the true prevalence of active HCV infection in the population studied. Future studies should incorporate HCV RNA testing to confirm active infection to improve the accuracy of prevalence estimates and better inform public health response (147).

Strengths

Despite these limitations, our study has notable strengths. To our knowledge, this is the first systematic review and meta-analysis that collated and evaluated existing data on the seroprevalence of HCV among blood donors in Africa. Additionally, we investigate the factors

driving regional variability in HCV seroprevalence. These findings provide valuable insights that inform region-specific health interventions, ensuring a more effective response to HCV transmission through blood transfusions across the continent.

Conclusion: This systematic review and meta-analysis found that the seroprevalence of HCV among blood donors is 2.45%, indicating a continued public health challenge. We observed substantial variations across African regions, with the highest prevalence reported in Western (3.33%) and Central Africa (2.69%) and the lowest in Southern Africa (0.29%). Our findings also demonstrate a statistically significant decline in HCV seroprevalence over time, suggesting the positive impact of improved screening protocols and public health interventions in some countries. However, the marked heterogeneity among studies and the underrepresentation of 22 African countries highlight critical gaps in surveillance and research. Moreover, most studies relied on serological tests, which may overestimate current infection and limit progress monitoring. These findings support the need to enhance hemovigilance systems, expand confirmatory HCV RNA testing, and ensure equitable access to early diagnosis and antiviral treatment. National responses must be country and regional tailored, grounded in updated data, and aligned with WHO`s 2030 HCV elimination goals to effectively address the burden of HCV.

Declarations

Role of the funding source

There was no specific funding for this research.

Contributors

Angelina Edna Quintas (AQ): Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing-original draft; Writing-review & editing.

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Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of Interests

The authors declare that they have no competing interests.

Acknowledgments

The authors want to acknowledge the Department of Community Medicine, Information and Decision in Health of the University of Porto and the Center for Health Technology and Services Research to conduct this systematic review and meta-analysis. We are grateful to the studies' authors included in this systematic review and Doctor Milaydis Sosa Napolskij, who proofread the manuscript's text.

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Supplementary Materials I

Supplementary material II
L1: List of included studies

Seroprevalence and Temporal Trends of Hepatitis C Virus in African Blood Donors: A Systematic Review and Meta-analysis

Authors: Angelina Edna Quintas, MD; Nelson Cuboia, MD, PhD; Lemuel Cordeiro, MD, PhD; António Sarmento, MD, PhD; Luís Azevedo, MD, PhD.

Supplementary Materials I

Table S1: Research query

Search	Query
#12	Search: **#9 OR #4 AND #5 OR #6 AND #7**
#11	Search: **#9 AND #10**
#10	Search: **#4 OR #5 OR #6 OR #7**
#9	Search: **#8 AND #3**
#8	Search: **#1 AND #2**
#7	Search: **((Syphilis OR Lues))**
#6	Search: **((Hepaciviruses OR (Hepatitis C Virus OR Hepatitis C viruses) OR (Hepatitis C-Like Virus OR Hepatitis C-Like Viruses))**
#5	Search: **((Hepatitis B virus OR Hepatitis B viruses) OR (Dane Particle OR Particle Dane) OR (Hepatitis Virus OR Homologous Serum))**
#4	Search: **((HIV OR Human Immunodeficiency Virus OR Human Immunodeficiency Viruses) OR (AIDS Virus OR AIDS Viruses) OR (Acquired Immune Deficiency Syndrome Virus OR Acquired Immunodeficiency Syndrome Virus) OR (Human T Lymphotropic Virus Type III OR Human T-Lymphotropic Virus Type III) OR (Lymphadenopathy-Associated Virus OR Lymphadenopathy Associated Virus OR Lymphadenopathy-Associated Viruses) OR (HTLV-III OR LAV-HTLV-III))**
#3	Search: **Algeria OR Angola OR ((Benin OR (Republic of Benin) OR Dahomey)) OR (Botswana OR Bechuanaland OR Kalahari) OR ((Burkina Faso OR (Upper Volta) OR (Burkina Fasso)) OR ((Burundi OR (Republic of Burundi) OR Urundi)) OR ((Cabo Verde) OR (Republic of Cape Verde) OR (Cape Verde)) OR ((Cameroon OR (Republic of Cameron) OR (United Republic of Cameroon) OR Cameroons)) OR ((Central African Republic) OR Ubangi-Shari) OR Chad OR ((Comoros OR (Iles Comores) OR (Comoro Islands) OR Mayotte)) OR ((Democratic Republic of Congo) OR Congo OR (Kinshasa) OR Zaire OR (Belgian Congo) OR Katanga)) OR ((Republic of Congo OR Republic of the**

Search	Query
	Congo OR Congo (Brazzaville)) OR ((Cote d'Ivoire OR (Ivory Coast) OR (Republic of Cote diIvoire)) OR ((Djibouti OR (Republic of Djibouti) OR (French Somaliland)) OR ((Egypt OR (Arab Republic of Egypt) OR (United Arab Republic)) OR ((Equatorial Guinea OR (Republic of Equatorial Guinea) OR (Spanish Guinea) OR (Guinea Spanish) OR (Rio Muni)) OR Eritrea OR (Eswatini OR Swaziland) OR ((Ethiopia OR (Federal Democratic Republic of Ethiopia)) OR ((Gabon OR (Gabonese Republic)) OR ((Gambia OR (Republic of the Gambia)) OR ((Ghana OR (Republic of Ghana) OR (Gold Coast)) OR ((Guinea OR (Republic of Guinea) OR (French Guinea)) OR ((Guinea-Bissau OR (Republic of Guinea-Bissau) OR (Portuguese Guinea)) OR ((Kenya OR (Republic of Kenya)) OR ((Lesotho OR Basutoland OR (Kingdom of Lesotho)) OR ((Liberia OR (Republic of Liberia)) OR Libya OR ((Madagascar OR (Malagasy Republic)) OR ((Malawi OR (Republic of Malawi) OR Nyasaland) OR ((Mali OR (Republic of Mali)) OR Mauritania OR ((Mauritius OR (Agalega Islands)) OR (Morocco OR Ifni) OR ((Mozambique OR (Republic of Mozambique) OR Mosambique OR Mocambique OR Moçambique OR (Portuguese East Africa)) OR ((Namibia OR (Southwest Africa) OR (Republic of Namibia) OR (South West Africa)) OR ((Niger OR (Republic of Niger)) OR ((Nigeria OR (Federal Republic of Nigeria)) OR ((Rwanda OR (Republic of Rwanda)) OR (Sao Tome and Principe) OR ((Senegal OR (Republic of Senegal)) OR Seychelles OR ((Sierra Leone) OR (Republic of Sierra Leone)) OR Somalia OR ((South Africa) OR (Union of South Africa) OR (Republic of South Africa)) OR (South Sudan) OR ((Sudan OR (Republic of the Sudan)) OR ((Tanzania OR (United Republic of Tanzania) OR Zanzibar OR Tanganyika)) OR ((Togo OR (Togolese Republic)) OR Tunisia OR ((Uganda OR (Republic of Uganda)) OR ((Zambia OR (Northern Rhodesia) OR (Republic of Zambia)) OR ((Zimbabwe OR (Zimbabwe Rhodesia) OR (Southern Rhodesia) OR (Republic of Zimbabwe))
#2	Search: ((Prevalence OR Prevalences) OR (Seroprevalence OR Seroprevalences) OR (Seroepidemiologic OR Seroepidemiological))
#1	Search: Blood AND ((Donor OR Donors) OR (Donation OR Donations))

Seroprevalence and Temporal Trends of Hepatitis C Virus in African Blood Donors: A Systematic Review and Meta-analysis

Authors: Angelina Edna Quintas, MD; Nelson Cuboia, MD, PhD; Lemuel Cordeiro, MD, PhD; António Sarmento, MD, PhD; Luís Azevedo, MD, PhD.

Supplementary material II

L1: List of included studies

1. Siraj N, Achila OO, Issac J, Menghisteab E, Hailemariam M, Hagos S, et al. Seroprevalence of transfusion-transmissible infections among blood donors at National Blood Transfusion Service, Eritrea: a seven-year retrospective study. BMC Infect Dis. 2018;18(1):264. Available from: https://pubmed.ncbi.nlm.nih.gov/29879912/. DOI: 10.1186/s12879-018-3174-x.
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[Mali data]

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[Niger data]

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[Rwanda data]

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[Burkina Faso data]

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[Democratic Republic of Congo data]

PUBLICAÇÃO 4

Seroprevalence of Human Immunodeficiency Virus in African Blood Donors: A Systematic Review and Meta-analysis. ***Angelina Edna Quintas***, Nelson Cuboia, Lemuel Cordeiro, António Sarmento, Luís Azevedo.

Publicado na revista *eBioMedicine part of The Lancet Discovery* Science em julho de 2024. (www.thelancet.com Vol 105 July, 2024).

Seroprevalence of human immunodeficiency virus in African blood donors: a systematic review and meta-analysis

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eBioMedicine
2024;105: 105210
Published Online xxx
https://doi.org/10.1016/j.ebiom.2024.105210

Summary

Background In developing countries, the safety of blood transfusions remains an important public health concern as it is associated with a higher risk of transfusion-transmissible infections (TTIs). In this study, we aimed to estimate the seroprevalence of HIV among blood donors in Africa and assess the temporal trends and regional differences within the continent through a systematic review and meta-analysis.

Methods Seven electronic databases (PubMed, Web of Science, Cochrane, Scopus, HINARI, Global Index Medicus and Clinical.Trial.gov) were searched for relevant studies for our research. We included all primary studies that estimated the seroprevalence of HIV among blood donors in Africa with an age population from 16 to 65 years old, without language restrictions, from inception up to March 1st 2024. The pooled seroprevalence was estimated through the DerSimonian-Laird random effects model. The temporal trends and regional differences were assessed through subgroup and meta-regression analysis.

Findings We obtained 122 studies that met our inclusion criteria, comprising 7,814,996 blood donors tested for HIV. Sixty-six percent of the studies were from Western and Eastern Africa. The pooled seroprevalence of HIV among blood donors in Africa was 2.66% (95% CI: 2.17–3.20%; I^2 = 99.80%, p < 0.01). The highest prevalence was observed in the Central African region, 3.28% (95% CI: 2.57%–4.06%), followed by the Eastern 3.21% (95% CI: 2.12%–4.52%), and the Western 2.66% (95% CI: 1.93%–3.49%) regions. Lower prevalences were observed in the Northern region, 0.57% (95% CI: 0.0%–2.10%), followed by the Southern African region with 0.45% (95% CI: 0.16%–0.86%). We observed a temporal decreased trend of HIV prevalence.

Interpretation The prevalence of HIV infection among African blood donors remains high and is not homogeneous across the continent. Efficient measures to strengthen HIV testing and prevent HIV transmission through blood transfusion are needed in Africa. Systematic review protocol registration: PROSPERO CRD42023395616.

Funding This article was supported by National Funds through FCT - Fundação para a Ciência e a Tecnologia,I.P., within CINTESIS, R&D Unit (reference UIDP/4255/2020).

Keywords: Blood donors; Prevalence; Human immunodeficiency virus; Africa; Systematic review

Introduction

Human immunodeficiency virus (HIV) infection in Africa is an enormous public health problem. Among the 39.0 million [33.1 million–45.7 million] people who lived with HIV in 2022 in the world, 25.6 million [21.6 million–30.0 million] were from Africa.[1,2] The African region remains most severely affected by this disease, with one in every 30 adults (3.2%) living with HIV and accounting for 2/3 of people living with HIV worldwide.[2] This high prevalence of HIV has several

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Research in context

Evidence before this study

A transfusion-transmitted infection (TTI) is any infection acquired through blood transfusion. Evidence shows that HIV might be transmitted through blood transfusion, and two-thirds of new cases of HIV globally are in Africa, where the demand for blood transfusion has increased. Knowledge of the global burden of HIV among blood donors in Africa is scarce. We searched in electronic databases: PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus and Clinicaltrials.gov; with the keywords "Blood" AND "Donors" AND "Seroprevalence" AND "Serologic Tests" AND "Human Immunodeficiency Virus" OR "HIV" AND "African Countries" to identify studies from inception through March 1st 2024. The research queries are in the Supplementary Materials in Table S1. We found only one systematic review and meta-analysis by Sydney Puerto-Meredith at the supranational level in Africa, published in 2023. The author assessed the prevalence of transfusion-transmitted infections, including HIV. However, this study was done only across countries in the South African Development Community (SADC), where they found the estimated prevalence of HIV among blood donors at 2% (95% CI: 1.0–4.0).

Added value of this study

Our systematic review and meta-analysis analyzed and synthesized the seroprevalence of HIV among blood donors across the African continent. We identified 122 eligible articles involving 7,814,996 participants. Only 30 (56%) of the 54 African countries were represented, and most of the studies were conducted in Western and Eastern Africa. We found a pooled prevalence of 2.66% (95% CI: 2.17–3.20%). In subgroup analyses, we found statistical differences in the seroprevalence of HIV among blood donors in Africa according to the study country, African region, and year of study publication. We found that the Central region had the highest seroprevalence of HIV, and we noted a high heterogeneity among the pooled studies (I^2 = 99.80%). Investigate the reasons for the variability across Africa and showed that more studies are needed, particularly concerning underrepresented African countries (Southern and Northern regions), to have a good overview of the seroprevalence of HIV in Africa among blood donors.

Implications of all the available evidence

The high prevalence of HIV observed in this population group in our study suggests once again that HIV transmission by blood transfusion should not be neglected. A high heterogeneity across the African continent, as found in this systematic review and meta-analysis, showed that, in Africa, we need to improve clinical diagnosis, strict selections of blood donors, screening methods, and health policies to ensure blood transfusion safety.

implications for the dynamics of HIV transmission in the population. With the increasing need for blood transfusion in Africa due to anemia, miscarriage, malnutrition, postpartum hemorrhage, and traffic accidents, the safety of blood transfusion has become extremely important in this context.[3] Since blood is an invaluable fluid that sustains life, it is considered an integral and essential element for the health system. Providing safe blood and preventing the transmission of infectious diseases are among the most important goals for health policy organizations.[4] However, blood products and blood transfusions are still responsible for 5–10% of HIV infections in Sub-Saharan Africa, and it varies from region to region, some with low and others with intermediate and high prevalence.[5] Infections such as Hepatitis B virus (HBV), Hepatitis C virus (HCV), and HIV are of great concern because of their prolonged viremia and latent status. Therefore, highly sensitive tests and the strict selection of low-risk blood donors are indispensable to guaranteeing efficacy in blood safety.[6,7]

The prevalence of HIV remains high in Africa, and with an increase in blood transfusion demand on the continent, ensuring blood transfusion safety remains a subject of concern.[6,7] Different studies on the prevalence of HIV among blood donors have been conducted in various African countries. For instance, the prevalence of HIV among blood donors is 2.69% in Ethiopia,[8] 2.0% in the South African Development Community region,[9] 2.21% in Burkina Faso,[10] and 0.18% in Eritrea.[11] However, a comprehensive study analyzing and synthesizing the available evidence on the prevalence of HIV among blood donors in Africa is still lacking. Such knowledge is pivotal for formulating targeted interventions and has implications for health policymakers to inform evidence-based strategies for blood safety enhancement in Africa.

Therefore, this study aimed to systematically analyze and synthesize the available evidence on the seroprevalence of human immunodeficiency virus among African blood donors and assess the temporal trends and regional differences within the continent. By systematically analyzing the available evidence, the study aims to contribute valuable insights into the dynamics of HIV transmission through blood transfusions, facilitating the identification of areas with heightened risk.

Methods

Eligibility criteria

We included primary studies (observational studies, cross-sectional studies, case–control, cohort study in blood donors of both genders in African Countries) with a full text published in any language from inception

through March 1st 2024, and having extractable data on the seroprevalence of HIV among blood donors in Africa aged 16–65 years old. Studies were excluded if: a) they were conducted among populations residing outside Africa; b) they were a case series, reviews, and editorial comments; and c) they had duplicated data.

Information sources

The studies included in this work were searched in seven electronic databases: PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus and Clinicaltrials.gov, and we manually searched in the included articles' references.

Search strategy

We combined controlled vocabulary and free-text terms related to the seroprevalence of HIV among African blood donors to identify potentially relevant studies from the electronic databases. The research queries we used are in the Supplementary Materials in Table S1.

Selection process

Two reviewers (AEQ, NC) carried out the study selection process independently. The differences in the selected studies were discussed to reach a consensus, and persistent disagreements were solved by a third reviewer (LA).

This study was part of a more extensive research that assessed the seroprevalence of Serologic Markers of Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Human Immunodeficiency Virus (HIV), and Syphilis in Blood Donors in Africa. Due to the considerable volume of results, we decided to split such a study into four separate analyses concerning transmitted blood infection diseases (Hepatitis B virus, Hepatitis C Virus, Syphilis, and HIV).

Data collection process

Two reviewers, AEQ and NC, independently extracted relevant data for each included study based on a predefined and agreed-upon data extraction form designed for this study. The difference in extracted data was discussed, and persistent disagreement was resolved by the third reviewer (LA).

Data items

For each included study, we extracted the following information: Author name, year of publication, date of participant enrolment, study design, name of the country and African region where the study was performed, location (unicentric or multicentric), setting

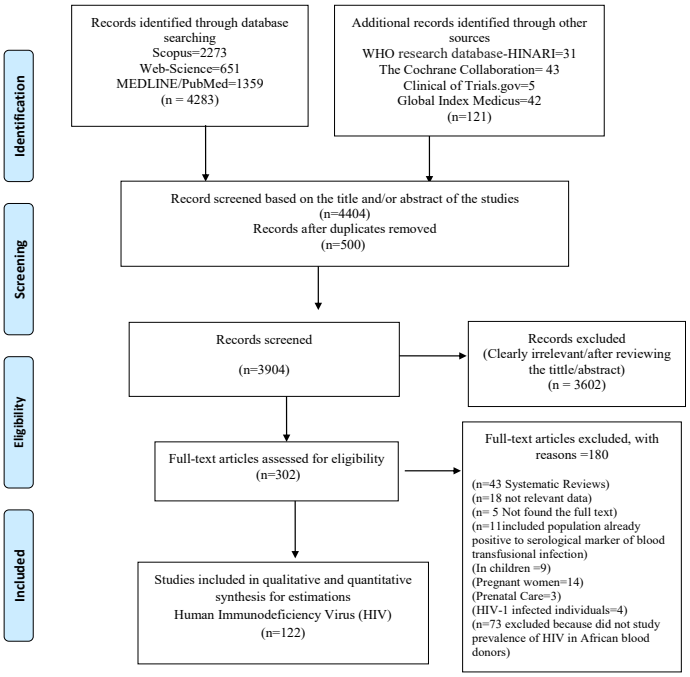


Fig. 1: **PRISMA flow diagram of studies reviewed, screened, and included.**

First author and colleagues	Year of publication	Study design	Country	Enrolment time	Sample size	Total participants in study (N)	Blood donors by sex male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HIV Diagnosis/ Screening methods 1	HIV Diagnosis/ Screening methods 2	Anti-HIV overall positivity rates (N)	Anti-HIV overall positivity rates (%)	Risk of Bias
Siraj N. et al.	2018	Retrospective	Eritrea	2010–2016	60,236	60,236	39,978 (66.3)	54,264	5972	–	ELISA	ELISA	182	0.3	Low
Abdella S. et al.	2020	Retrospective	Ethiopia	2014–2019	554,954	554,954	354,707 (63.9)	520,658	34,296	–	ELISA	ELISA	2220	0.4	Low
Buseri F. et al.	2009	Prospective	Nigeria	2007–2008	1410	1410	1200 (85.1)	–	–	–	ELISA	ELISA	44	3.1	Moderate
Okoroiwu H. et al.	2018	Both	Nigeria	2005–2016	24,979	24,979	24,654 (98.7)	137	15,487	9355	RDT HIV 1/2+Uni-Gold	RDT HIV 1/2+Uni-Gold	1044	4.2	Low
Fesehaye N. et al.	2011	Retrospective	Eritrea	2006–2009	29,501	29,501	–	23,385	6116	6116	–	–	52	0.18	Moderate
Nzaji M. et al.	2013	Retrospective	Democratic Republic of Congo	2008	1015	1015	965 (95)	493	522	–	Determine ™HIV-1/2	Determine ™HIV-1/2	29	2.9	Moderate
Deressa T. et al.	2018	Retrospective	Ethiopia	2014–2017	8460	8460	5644 (95.1)	–	–	–	4th Gen Elisa	4th Gen Elisa	21	0.25	Moderate
Diarra A. et al.	2009	Retrospective	Mali	2007	25,543	25,543	–	8094	17,449	–	Determine ™HIV-1/2	Determine ™HIV-1/2	660	2.6	Moderate
Stoka J. et al.	2011	Retrospective	Mozambique	2009	750	679	–	–	–	–	RDT HIV-1/2	RDT HIV-1/2	58	8.5	Moderate
Ankouane F. et al.	2016	Retrospective	Cameroon	2013	9024	9024	8453 (93.6)	249	8767	–	RDT HIV-1/2+ELISA	RDT HIV-1/2+ELISA	301	3.3	Moderate
Abate M. et al.	2016	Retrospective	Ethiopia	2010–2014	6827	6827	6648 (97.3)	–	–	–	ELISA	ELISA	216	3.16	Moderate
Mohammed Y. et al.	2016	Retrospective	Ethiopia	2010–2013	4224	4224	4171 (97.4)	85	4139	–	ELISA	ELISA	6/487	1.2	Moderate
Tessema B. et al.	2010	Retrospective	Ethiopia	2003–2007	6361	6361	5592 (98.7)	–	–	–	ELISA	ELISA	239	3.8	Moderate
Kubio C. et al.	2012	Retrospective	Ghana	2009	843	719	–	–	201	518	RDT HIV-1/2	RDT HIV-1/2	33/846	3.9	Moderate
Mavenyengwa R. et al.	2014	Retrospective	Namibia	2012	24,761	24,761	13,054 (52.7)	–	–	–	RDT HIV-1/2	RDT HIV-1/2	75/24,761	0.3	High
Keleta Y. et al.	2019	Retrospective	Eritrea	2014–2017	1939	1939	1710 (88.2)	781	1158	1158	RDT HIV-1/2 + Uni-Gold	RDT HIV-1/2 + Uni-Gold	16	0.8	Moderate
Wongjaroupong N. et al.	2021	Retrospective	Burkina Faso	2009–2013	166,681	166,681	119,437 (71.7)	–	–	–	ELISA	ELISA	3501	2.1	Moderate
Nagalo M. et al.	2011	Retrospective	Burkina Faso	2009	4520	4520	3418 (75.6)	–	–	–	ELISA	ELISA	204	2.21	Low
Peliganga L. et al.	2021	Retrospective	Angola	2005–2020	57,979	57,979	41,414 (71.4)	–	–	–	RDT HIV-1/2	RDT HIV-1/3	1219	2.1	Low
Kabinda J. et al.	2014	Retrospective	Democratic Republic of Congo	2011	593	568	417 (73.4)	513	4	60	Determine HIV-1	Determine HIV-2	9/568	1.6	High
Rearmbiah K.L. et al.	2014	Retrospective	Gabon	2009–2011	46,018	46,018	31,846 (69.2)	19,378	21,696	–	RDT + western blot	RDT + western blot	798	3.09	Moderate
Yami A. et al.	2011	Retrospective	Ethiopia	2010	9204	6063	4802 (79.2)	–	–	–	ELISA	ELISA	129	2.1	Moderate
Bisseye C. et al.	2018	Retrospective	Gabon	2012–2017	5706	5076	4765 (93.9)	–	5706	5706	Determine HIV-1	Determine HIV-2	176	3.1	Low
Kengne M. et al.	2018	Prospective	Cameroon	2014	265	265	242 (91.3)	30	235	235	ELISA	ELISA	14	5.3	High
Ampofo W. et al.	2002	Retrospective	Ghana	1999	3131	808	762 (94.3)	30	778	–	Agglutination assay kits	Agglutination assay kits	31	3.8	High

(Table 1 continues on next page)

First author and colleagues	Year of publication	Study design	Country	Enrolment time	Sample size	Total participants in study (N)	Blood donors by sex male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HIV Diagnosis/ Screening methods 1	HIV Diagnosis/ Screening methods 2	Anti-HIV overall positivity rates (N)	Anti-HIV overall positivity rates (%)	Risk of Bias
(Continued from previous page)															
Ramos J. et al.	2016	Retrospective	Ethiopia	2007–2012	9493	9493	–	–	–	–	Immunochromatography	Immunochromatography	19/2605	0.7	High
Negash M. et al.	2019	Retrospective	Ethiopia	2017–2018	338	310	198 (63.9)	–	–	–	3rd Gen ELISA	3rd Gen ELISA	8	2.6	Moderate
Jary A. et al.	2019	Retrospective	Mali	2018	8207	8059	7157 (88.8)	160	7898	–	RDT HIV-1/2	RDT HIV-1/2	174	2.16	Moderate
Xie D. et al.	2015	Retrospective	Equatorial Guinea	2011–2013	2937	2937	2256 (76.8)	–	–	–	ELISA	ELISA	230	7.83	High
Vermeule M. et al.	2017	Retrospective	South Africa	2012–2015	3,075,422	397,640	177,729 (44.7)	–	–	–	Western blot	Western blot	4481	1.13	Moderate
Sumbu B. et al.	2018	Retrospective	Democratic Republic of Congo	2003–2006 and 2008–2013	26,341	26,341	21,200 (80.5)	8418	–	17 923	3rd Gen ELISA	3rd Gen ELISA	576	2.2	Low
Tigabu A. et al.	2019	Retrospective	Ethiopia	2018	5983	5983	5118 (85.5)	–	–	–	ELISA	ELISA	147	2.5	Moderate
Boushab B. et al.	2017	Retrospective	Mauritania	2010–2015	1123	1123	182 (16.2)	–	–	–	Determine HIV-1/ 2+Immunochromatography	Determine HIV-1/ 2+Immunochromatography	13	1.2	Moderate
Uwingabiye J. et al.	2016	Retrospective	Morocco	2010–2012	25,661	25,661	24,378 (95)	–	–	–	4 th Gen ELISA	4 th Gen ELISA	4	0.15	High
Wamamba D. et al.	2017	Retrospective	Kenya	2015	3690	2046	1360 (66.5)	–	–	–	4th Gen ELISA	4th Gen ELISA	50	2.4	Low
Dogbe E. et al.	2015	Retrospective	Ghana	–	300	300	–	–	–	–	3rd Gen ELISA	3rd Gen ELISA	3	1	Moderate
Mabunda N. et al.	2022	Prospective	Mozambique	2014–2015	2783	2783	2320 (83.4)	1146	1608	–	UNIGOLD + ELISA	UNIGOLD + ELISA	127	4.6	Moderate
Yooda A. et al.	2019	Retrospective	Burkina Faso	2015–2017	84,299	84,299	59,979 (71.2)	–	–	–	RDTs + ImmunoComb	RDTs + ImmunoComb	1231	1.80	Moderate
Sharew B. et al.	2017	Retrospective	Ethiopia	2008–2012	9384	9384	7514 (80.1)	–	–	–	4th Gen Elisa	–	476	5.1	Low
Berg K. et al.	2021	Retrospective	South Africa	2017	1,007,580	1,007,580	–	–	–	–	ELISA	ELISA	1462	0.18	Moderate
Jacobs B. et al.	1997	Retrospective	Tanzania	1992	2333	1205	1074 (89.1)	–	–	–	2sd Gen ELISA	2sd Gen ELISA	73	–	Moderate
Mohamed Z. et al.	2019	Retrospective	Tanzania	2016–2017	6402	6402	5383 (84.1)	763	763	5634	ELISA	ELISA	107/6402	1.7	High
Hussein E. et al.	2014	Retrospective	Egypt	2006–2012	308,762	308,762	–	195 635	–	113 127	ELISA	ELISA	220	0.07	Moderate
Degefa B. et al.	2018	Retrospective	Ethiopia	2011–2014	10,728	10,728	3750 (35)	6302	4426	–	ELISA	ELISA	111	1.03	Moderate
Koné M.C. et al.	2012	Retrospective	Mali	2007–2010	2946	2946	–	27	121	121	Determine HIV-1/2+ ImmunoComb	Determine HIV-1/2+ ImmunoComb	26	0.88	Moderate
Mogtomo M. et al.	2009	Prospective	Cameroon	1995–2004	1513	304	1171/ 1513 (77.3)	80	1433	1433	ELISA	ELISA	24/304	7.89	High
Tounkara A. et al.	2009	Retrospective	Mali	2001–2002	11,592	11,592	10,108 (87.2)	–	–	–	ELISA	ELISA	518	4.5	High
Diro E. et al.	2008	Retrospective	Ethiopia	2003–2004	1761	600	537 (89.5)	–	–	–	ELISA	ELISA	27	4.5	Moderate
Tagny C. et al.	2020	Retrospective	Cameroon	2012	356	131	85 (64.9)	52	79	79	RDT + Determine HIV-1/2	RDT + Determine HIV-1/2	76/131	58	High
Urio L. et al.	2015	Retrospective	Tanzania	2011–2012	600	139	179/600 (29.8)	–	–	–	ELISA	ELISA	(3)209/596	35.1	Moderate

(Table 1 continues on next page)

First author and colleagues	Year of publication	Study design	Country	Enrolment time	Sample size	Total participants in study (N)	Blood donors by sex male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HIV Diagnosis/ Screening methods 1	HIV Diagnosis/ Screening methods 2	Anti-HIV overall positivity rates (N)	Anti-HIV overall positivity rates (%)	Risk of Bias
(Continued from previous page)															
Nkansah C. et al.	2022	Both	Ghana	2010–2018	3306	3306	2739 (82.8)	–	–	–	Immunochromatography	Immunochromatography	359/3306	10.9	Low
Ambachew H. et al.	2018	Retrospective	Ethiopia	2016	2237	2237	–	–	–	–	ELISA	ELISA	38	1.7	Low
Motayo B. et al.	2015	Prospective	Nigeria	2013	130	130	126 (96.9)	–	130	–	RDT HIV-1/2+Determine HIV-1/2	RDT HIV-1/2+Determine HIV-1/2	8	6.2	Moderate
Seck M. et al.	2016	Prospective	Senegal	–	8219	8048	6439 (80)	–	–	–	4th Gen Elisa	4th Gen Elisa	4	0.05	Moderate
Kabeya C. et al.	1998	Retrospective	Democratic Republic of Congo	1997	1970	356	232 (65.2)	356	–	–	ELISA	ELISA	11	3.0	Moderate
Olusola B. et al.	2021	Prospective	Nigeria	2015	1028	138	136 (98.6)	138	–	–	ELISA	ELISA	9	6.52	High
Sentjens R. et al.	2002	Retrospective	Ethiopia	1991	4830	2610	2069 (79.3)	2610	–	–	ELISA	ELISA	155/2610	5.9	Moderate
Savarit D. et al.	1992	Retrospective	Côte d'Ivoire	1991	10,907	10,907	–	–	–	–	ELISA	ELISA	681	12.2	Moderate
Schutz R. et al.	1993	Retrospective	Côte d'Ivoire	1991	30,165	1257	1094 (87)	–	15 685	15 685	ELISA	ELISA	143	11.4	Moderate
Lidenge S. et al.	2020	Retrospective	Tanzania	2019	504	504	431 (85.5)	–	–	–	ELISA	–	21	4.2	Low
Yambasu E. et al.	2018	Retrospective	Sierra Leone	2016	16,865	16,807	13,426 (79.9)	1986	–	14 760	RDTs	RDTs	473/ 16,806	2.8	High
Simpore A. et al.	2014	Retrospective	Burkina Faso	2011–2012	6375	6375	–	–	–	–	4th Gen Elisa	4th Gen Elisa	3	1.2	Moderate
Tagny C. et al.	2016	Retrospective	Cameroon	2011–2015	1704	1596	1313 (82.3)	403	1193	1193	RDTs + EIA	RDTs + EIA	19	1.2	Moderate
Ahmed E. et al.	2020	Retrospective	Sudan	2017	10,897	10,897	10,897 (100)	10,897	–	–	Immunochromatography test	Immunochromatography test	285	2.61	Moderate
Onyango C. et al.	2018	Retrospective	Kenya	2015–2016	1215	1215	700 (57.6)	–	–	–	ELISA	ELISA	14	1.5	Moderate
Bisetegen F. et al.	2016	Retrospective	Ethiopia	2015	390	390	291 (74.6)	–	–	–	4th Gen Elisa	4th Gen Elisa	21	6.4	High
Ibrahim Y. et al.	2014	Retrospective	Egypt	2010–2011	17,118	17,118	13,918 (81.3)	2101	15,017	15,017	ELISA	ELISA	2	0.01	Moderate
Matee M. et al.	2006	Retrospective	Tanzania	2005	1599	1597	1424 (89.2)	474	1125	–	ELISA	ELISA	83	3.8	Moderate
Assefa A. et al.	1994	Prospective	Ethiopia	1989–1993 and 1991–1993	3696	3696	3066/ 3696 (82.9)	–	–	–	ELISA	ELISA	326/3066	10.6	Low
Mabayoje O.V. et al.	2018	Prospective	Nigeria	2004–2005	2496	2496	1988 (79.6)	VNRBD	RD	–	ELISA	ELISA	64	3.2	Low
Newman M.L. et al.	2001	Retrospective	Mozambique	1997–1999	797	110	–	VNRBD	–	–	–	–	43	39.1	Moderate
Fang T.C. et al.	2003	Retrospective	South Africa	1999	892,077	19,709	–	VNRBD	–	–	EIA	EIA	162	0.8	Low
Rahlenbeck I S. et al.	2015	Retrospective	Ethiopia	1994–1995	2186	549	–	VNRBD	–	–	3rd Gen ELISA	3rd Gen ELISA	317	28.7	Low
Mole S. et al.	2011	Retrospective	Cameroon	2009	5058	5058	4025 (79.6)	1545	–	3513	ELISA	ELISA	273	5.4	Low
Nnodu O. et al.	2003	Prospective	Nigeria	1990–2002	20,574	20,574	–	VNRBD	–	–	ELISA	ELISA	979	60.5	Moderate
Jeremiah A.Z. et al.	2011	Retrospective	Nigeria	2010–2011	266	266	244 (91.7)	VNRBD	–	–	ELISA	ELISA	7	2.6	Moderate

(Table 1 continues on next page)

First author and colleagues	Year of publication	Study design	Country	Enrolment time	Sample size	Total participants in study (N)	Blood donors by sex male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HIV Diagnosis/ Screening methods 1	HIV Diagnosis/ Screening methods 2	Anti-HIV overall positivity rates (N)	Anti-HIV overall positivity rates (%)	Risk of Bias
(Continued from previous page)															
Nwankwo E. et al.	2012	Retrospective	Nigeria	2008	280	280	276 (98.6)	61	62	157	Determine HIV 1/2	Determine HIV 1/2	4	1.4	High
Eller A.L. et al.	2007	Retrospective	Uganda	–	5252	940	747 (79.5)	VNRBD	–	–	EIA	EIA	72	1.4	High
Ndilu K.L. et al.	2016	Retrospective	Democratic Republic of Congo	2012–2013	372	372	252 (67.7)	VNRBD	–	–	Determine R + Unigold R	Determine R + Unigold R	11	3.2	High
Kania D. et al.	2009	Retrospective	Burkina Faso	2002	500	500	–	500	–	–	4th Gen ELISA	4th Gen ELISA	49	9.8	Moderate
Mbanya N.D. et al.	2003	Retrospective	Cameroon	2001	264	252	197 (78.2)	VNRBD	–	–	RDT + Determine HIV-1/ 2+ELISA	RDT + Determine HIV-1/ 2+ELISA	20	7.9	High
Casteling A. et al.	1998	Retrospective	South Africa	–	532	532	275 (51.7)	VNRBD	–	FRD	ELISA	ELISA	5/510	1.0	Moderate
Gudo S.E. et al.	2009	Retrospective	Mozambique	2006	2019	1535	1616/ 1989 (81.2)	VNRBD	–	–	EIA	EIA	107	5.72	Moderate
Bengue M.K A. et al.	2008	Retrospective	Côte d'Ivoire	2008	2866	2866	35 (1.2)	VNRBD	–	–	EIA	EIA	2	4.6	Moderate
Maida. J.M. et al.	2000	Retrospective	Malawi	1996	100	100	–	–	–	–	ELISA + Wersten blot	ELISA + Wersten blot	20	20	Moderate
Ogunkolo O.F. et al.	2006	Retrospective	Nigeria	–	2532	2532	–	VNRBD	–	–	Immunocomb II + Recombigen HIV-1/HIV-2 RDT	Immunocomb II + Recombigen HIV-1/HIV-2 RDT	22	0.87	High
Sarkodie F. et al.	2001	Retrospective	Ghana	1999	3264	3264	–	1492	1772	–	EIA	EIA	48	2.4	Moderate
Allain J. et al.	2010	Retrospective	Mali	2010	25,543	25,543	–	8094	17,449	–	–	–	660	4.6	Low
Allain J. et al.	2010	Retrospective	Cameroon	2010	3325	3325	–	272	3053	–	–	–	125	7.7	Low
Allain J. et al.	2010	Retrospective	Ghana	2010	11,000	11,000	–	6640	4360	–	–	–	119	2.1	Low
Allain J. et al.	2010	Retrospective	Guinea	2010	10,740	10,740	–	1784	8956	–	–	–	68	2	Low
Sarkodie F. et al.	2016	Retrospective	Ghana	2014	2455	2455	1959 (79.8)	1080	–	1133	–	–	64/2455	2.6	Low
Allain J. et al.	2010	Retrospective	Ghana	2008	11,000	11,000	7901 (71.8)	6640	4360	–	Determine anti-HIV	Determine anti-HIV	119	2.13	Low
Moore A. et al.	2021	Retrospective	Kenya	1994	1877	1877	_	–	–	–	EIA		120	6.4	
Loriette M. et al.	2015	Retrospective	Cameroon	2013	2326	2326	_	–	–	–	Determine HIV 1/2	Vikia HIV 1/2	51	2.2	Moderate
Jager H. et al.	1990	Retrospective	Democratic Republic of Congo	1989	2237	2237	2031 (90.8)	275	571	1391	Western blot	Western blot	107	4.8	
Dionne-Odom J. et al.	2016	Retrospective	Cameroon	2014	3364	3364	_	3364	–	–	Determine	Second rapid HIV test	74	2.2	Low
Ogbenna A.A. et al.	2022	Retrospective	Nigeria	2015–2019	45,002	45,002	_	–	–	–	Bioelisa HIV 1 + 2 Ag/Ab	Bioelisa HIV 1 + 2 Ag/Ab	617	1.37	Moderate
Mapako T. et al.	2013	Retrospective	Zimbabwe	2002–2010	550,753	550,753	_	550,753	–	–	Architect HIV Ag/Ab Combo assay	Architect HIV Ag/Ab Combo assay	3323	0.6	Moderate
McFarland W. et al.	1998	Retrospective	Zimbabwe	1994–1995	1199	1199	_	1199	–	–	ELISA	ELISA	180	15	Low
Rerambiah K.L. et al.	2014	Retrospective	Gabon	NA	775	775	552 (71.2)	–	–	–	Genscreen Ultra HIV Ag-Ab from Bio-Rad	Genscreen Ultra HIV Ag-Ab from Bio-Rad	15	1.94	Moderate
Croce F. et al.	2007	Retrospective	Tanzania	2002	326	326	266 (81.6)	–	–	–	western blot	western blot	7	2.1	Moderate

(Table 1 continues on next page)

First author and colleagues	Year of publication	Study design	Country	Enrolment time	Sample size	Total participants in study (N)	Blood donors by sex male N (%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	HIV Diagnosis/ Screening methods 1	HIV Diagnosis/ Screening methods 2	Anti-HIV overall positivity rates (N)	Anti-HIV overall positivity rates (%)	Risk of Bias
(Continued from previous page)															
Bélec L. et al.	1998	Retrospective	Central African Republic	1996–1996	149	149	_	–	–	–	Western blot	Western blot	3	6.0	High
Schoub B.D. et al.	1992	Retrospective	South Africa	1991	117	117	_	–	–	–	ELISA	ELISA	1	0.7	High
Fischer R.P. et al.	1995	Prospective	Democratic Republic of Congo	1989–1992	2453	2453	_	–	–	2453	_	_	138	5.6	Moderate
Seri B. et al.	2018	Retrospective	Côte d'Ivoire	1992–2012	422,319	422,319	312,516 (74)	422,319	–	–	ELISA	ELISA	10,610	2.5	Moderate
Ankouane F. et al.	2015	Retrospective	Cameroon	2013	9024	9024	8453 (93.7)	249	–	8767	Elisa	Elisa	301	3.2	Moderate
Kebede E. et al.	2020	Retrospective	Ethiopia	2018	384	384	213 (55.5)	384	–	–	ELISA	ELISA	1	0.26	Moderate
Addai-Mensah O. et al.	2015	Retrospective	Ghana	2014	400	400	356 (89)	200	–	200	Determine® HIV	Determine® HIV	7	1.75	Moderate
Mayaki Z. et al.	2012	Retrospective	Niger	2010	3213	3213	2574 (80.1)	2204	–	1009	HIV Ag-Ab	HIV Ag-Ab	52	1.62	Moderate
Namululi B.A. et al.	2012	Retrospective	Democratic Republic of Congo	2001–2005	7442	7442	2301 (30.9)	2898	–	382	ELISA	ELISA	70/7271	1.0	Moderate
Abebe M. et al.	2021	Retrospective	Ethiopia	2015–2019	17,810	17,810	12,480 (70.1)	–	–	–	ELISA	ELISA	222	1.25	Low
Yooda P.A. et al.	2018	Retrospective	Burkina Faso	2017	989	989	655 (66.2)	–	–	–	p24 antigen	p24 antigen	25	2.5	High
Abebe M. et al.	2020	Retrospective	Ethiopia	2015–2019	17,810	17,810	12 480 (70.1)	–	–	–	ELISA	ELISA	222	1.25	Low
Moukoko C. et al.	2014	Retrospective	Cameroon	2012	477	477	381 (79.8)	50	–	427	4th Gen ELISA	4th Gen ELISA	8	1.9	Moderate
Mabayoje O.V. et al.	2010	Retrospective	Nigeria	2003	297	297	137 (46.0)	–	–	–	ELISA	ELISA	0	0	High
Quintas E.A. et al.	2023	Retrospective	Angola	2011–2016	2734	2734	2467 (90.0)	66	–	2668	ELISA	ELISA	191	7.0	Low
Djoudi F.et al.	2023	Both	Algeria	2010–2019	140,168	140,168	111,461 (79.5)	–	–	–	3rd Gen ELISA	3rd Gen ELISA	108	0.077	Low
Mangala C.et al.	2023	Retrospective	Gabon	2020–2021	381	381	256 (67.2)	86	–	295	4th Gen ELISA	4th Gen ELISA	22	1.4	High
Singogo E.et al.	2023	Retrospective	Malawi	2015–2021	204,920	204,920	158,508 (77.4)	–	–	–	ULTRA HIV EIA	ULTRA HIV EIA	675	2.4	Low
Gadji M.et al.	2023	Retrospective	Senegal	2019–2021	5002	5002	3746 (75.0)	2303	–	2699	ChemiflexTM	ChemiflexTM	21	1.8	Moderate
Jacobs G.et al.	2024	Retrospective	South Africa	2012–2016	515,945	515,397	228,059 (44.3)	515,397	–	–	NAT and InnoLIA	NAT and InnoLIA	5790	1.12	Low

Enzyme-Linked Immunosorbent Assay (ELISA), *gen* generation, –EIA based rapid immunochromatographic rapid kits, RDTs (rapid diagnostic tests), HBV hepatitis B virus, HBsAg-Hepatitis B surface antigen, HCV- hepatitis C virus InnoLIA (Innogenetics), HV- human immunodeficiency virus, Real-time polymerase chain reaction (RT-PCR) assay; –*Treponema pallidum* Haemaglutination Assay (TPHA) test; Veneral Disease Research Laboratory (VDRL) test and Rapidplasma Reagin test (RPR); Nucleic acid amplification testing (NAT), Line immunoassay (InnoLIA); Chemiflex™, chemiluminescence technology to screen for infectious markers.

Table 1: **Characteristics of all Studies included in the systematic review and meta-analysis of TTIs (Seroprevalence of Human Immunodeficiency Virus) among African blood donors.**

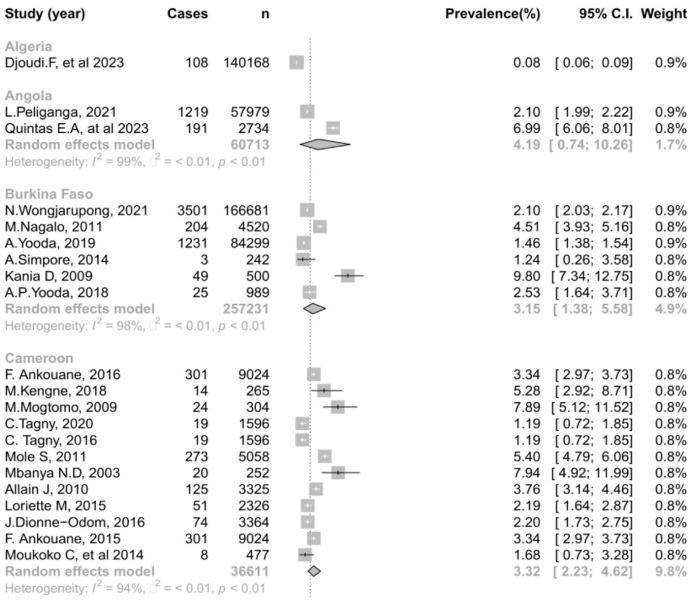


Fig. 2: **Forest plot of the pooled seroprevalence of Human Immunodeficiency Virus in African donors by country; Random-effect model: subgroup analysis by region; ES-estimated prevalence of HIV; 95% CI: 95% Confidence Interval; n: sample size**.

(urban or rural area), the total number of participants for each study, the total number of blood donors who tested positive for HIV, age and sex, type of blood donors (VNRBD-Voluntary Non-Remunerated Donors, RD- Replacement or Paid Donors/FD and FD-Family Donors), and the method used for screening and HIV diagnosis. This data was stored in the Microsoft Excel 2021 spreadsheet (Microsoft Corporation, Redmond, Washington, USA).

In our study, we defined study location as unicentric if the study was carried out in a single center or one hospital. In contrast, a multicentric study meant that the studies had been conducted in multiple centers or hospitals. The setting variable refers to whether the study was conducted in an urban or rural area.

Study risk of bias assessment

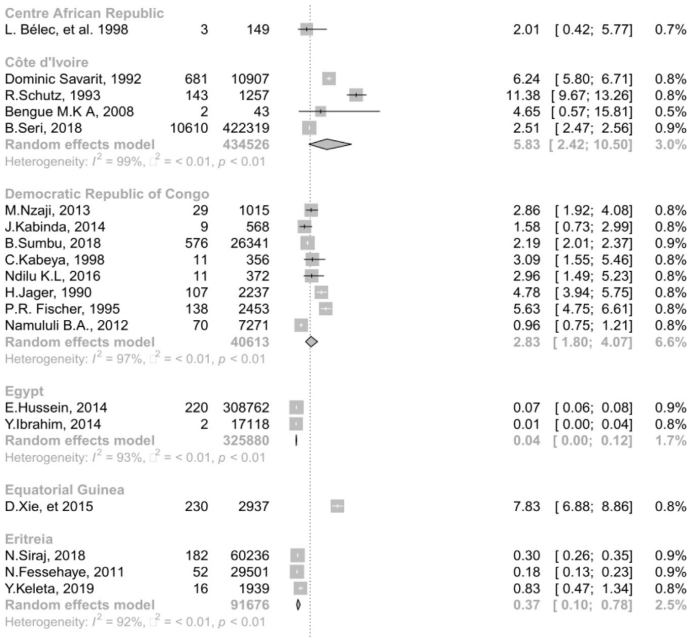
Two reviewers, AEQ and NC, independently assessed the quality of each included study using the risk of bias tool SeroTracker-RoB: a decision rule-based algorithm for reproducible risk of bias assessment of seroprevalence studies.[12] The differences in the quality assessment of the included studies were discussed, and persistent disagreement was resolved by the third reviewer (LA). This tool derives from the Joanna Briggs Institute Checklist for Prevalence Studies and asks nine questions to assess the risk of bias. The questions are a) Was the sample frame appropriate to address the target population? b) Were study participants recruited in an appropriate way? c) Was the sample size adequate? d) Was the data analysis conducted with sufficient coverage of the identified sample? e) Were valid methods used for the identification of the condition? f) Was the condition measured in a standard, reliable way for all participants? g) Was there appropriate adjustment for test characteristics? h) Was there appropriate adjustment for population characteristics? i) Was the response rate adequate, and if not, was the low response rate unlikely to introduce bias? and the last was the assessment of the overall risk of bias (lower, moderate, high and unclear) according to the automatic scores generated from the responses of the previous nine items.

Effect measures

In this study we used the proportion of blood donors who tested positive for HIV as the effect measure of our meta-analysis.

Synthesis methods

All the data were analyzed with R software version 4.3.2 (2023-10-31) using the meta package and the functions



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for meta-analysis of proportions.[13] To estimate the pooled seroprevalence of HIV among African blood donors, we used the DerSimonian-Laird random effect model,[14] and the proportions were estimated based on Freeman-Tukey double arcsine transformation (FTT).[15] The findings were presented with 95% confidence intervals.

We calculated the Cochrane Q test and I^2 statistic (percentage of total variability due to true heterogeneity, that is, to between-studies variability) to assess heterogeneity and its relative magnitude[16] and performed subgroup and sensitivity analyses to investigate the potential explanatory/moderator variables of the observed heterogeneity. Because we are analyzing and synthesizing prevalence studies from all of Africa and several different countries, we inherently assumed the presence of heterogeneity, and we mainly focused our analysis and results on subgroups and the assessment of moderators of heterogeneity.

The subgroup analyses were stratified by country, African region, and year of publication. The years of publication were categorized into binary variables (before and after 2010). This cut-off was chosen based on the distribution of the number of studies by year. Before 2010, we had a very low number of studies (less than six per year), whereas after 2010, we had more than ten studies per year. To determine the moderators of the heterogeneity and to assess the temporal trends and regional differences in our study, we performed a meta-regression analysis using the following variables: year of study publication and African region (Western, Northern, Eastern, Central, and Southern), risk of bias, study location (unicentric and multicentric), setting (Urban and Rural), proportion of men, age, type of blood donors and country where the study was performed.

We mapped the spatial pattern of the pooled estimates of seroprevalence of HIV African blood donors by country. The map was created using the Quantum Geographic Information System (QGIS) software.[17]

Reporting bias assessment

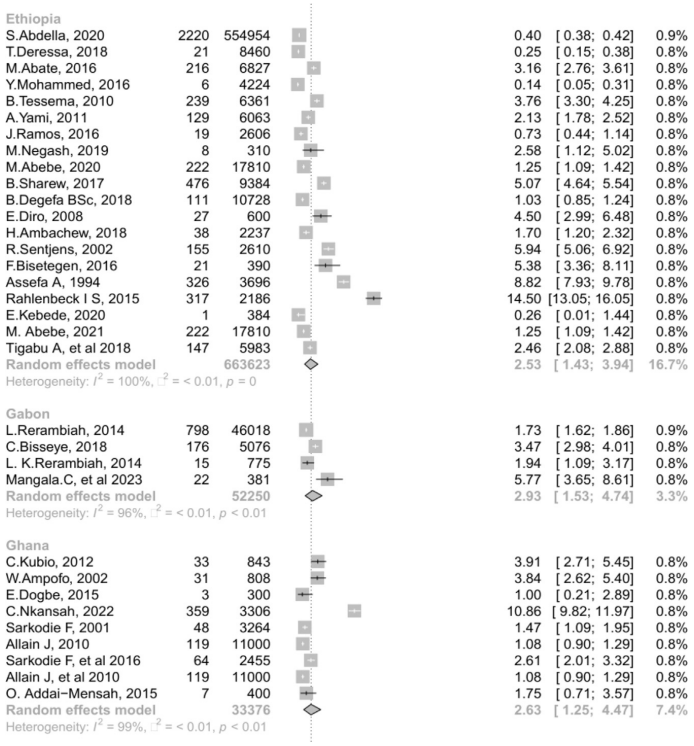
The publication bias was assessed through a funnel plot and by Egger's statistics regression test.

Role of the funding source

This article was supported by National Funds through FCT - Fundação para a Ciência e a Tecnologia,I.P., within CINTESIS, R&D Unit (reference UIDP/4255/2020).

Ethics

This study was a systematic review and meta-analysis. Therefore, ethical approval is not applicable.



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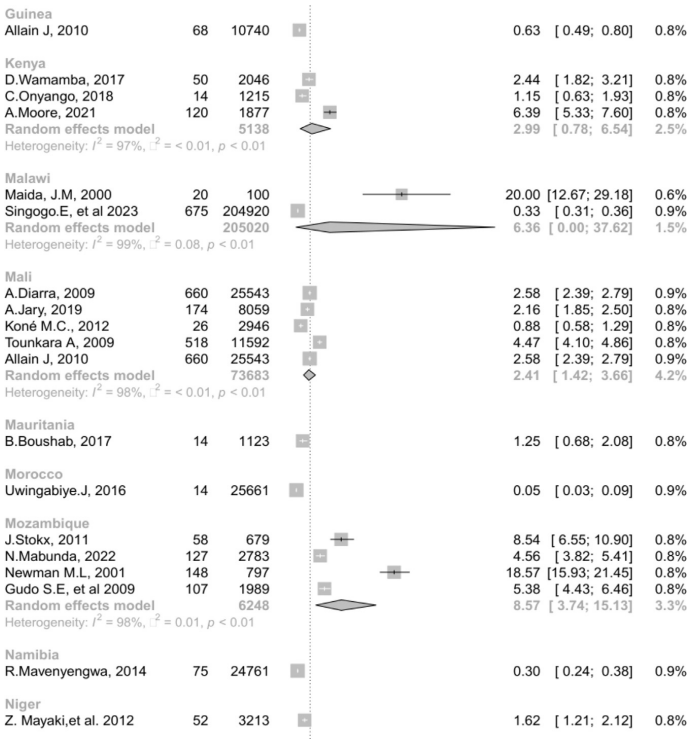
Results

Four thousand four hundred and four records (4404) were identified through database and manual searching, and 500 articles were excluded. The title and abstract of the remaining 3904 were screened, and 3602 articles were excluded as they did not meet the inclusion criteria and were found to be irrelevant to our study. The remaining 302 references were assessed for eligibility through the complete text examination, and 180 were excluded because they did not meet our inclusion criteria. The remaining 122 studies were considered for qualitative and quantitative synthesis, involving 7,814,996 participants. Among those 180 studies that did not meet our inclusion criteria, 73 did not study the prevalence of HIV among blood donors; 43 were systematic reviews[8,18–50]; 18 studies did not have relevant data[51–66]; five studies did not have their full text available[32,48,67–71]; 11 studies included population already positive for HIV[67,71–75]; nine studies included children[53,54,61,72]; one study presented individuals aged up to 80 years,[62,75] one study included age over seven years and less than 89 years[60] and one study had duplicate data[76]; 14 studies included pregnant women[60,77–79]; and the other four studies had HIV-1 infected individuals,[73,80] (See Fig. 1).

Study characteristics

Table 1 shows the characteristics of the studies included in this work. Thirty (56%) of the 54 African countries are represented in the 122 included studies. Most of the studies were conducted in Western, 41 (33.61%), and Eastern Africa, 40 (32.79%), followed by the Central 28 (22.95%), and lastly, the Southern seven (5.74%) and Northern six (4.92%) African regions. The year of study publication ranged from 1990 to 2024. Most of the studies, 91 (74.59%), were published after 2010. The average proportion of men was 60.01%.

Most studies had a moderate risk of bias 65 (53.28%), followed by a low risk of bias 31 (25.41%), and lastly by a high risk of bias 24 (19.67%). In two studies (1.64%), the risk of bias could not be assessed because information was incomplete. Regarding the type of



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donors, 65 (53.28%) of studies included only voluntary blood donors, 23 (18.85%) included only family donors, and 34 (27.87%) included both family and voluntary blood donors. Concerning the location, 68 (55.73%) studies were multicentric studies, while 53 (43.44%) were unicentric studies. The average age of the included studies was 28.21 years old, with a standard deviation of 3.48 years old.

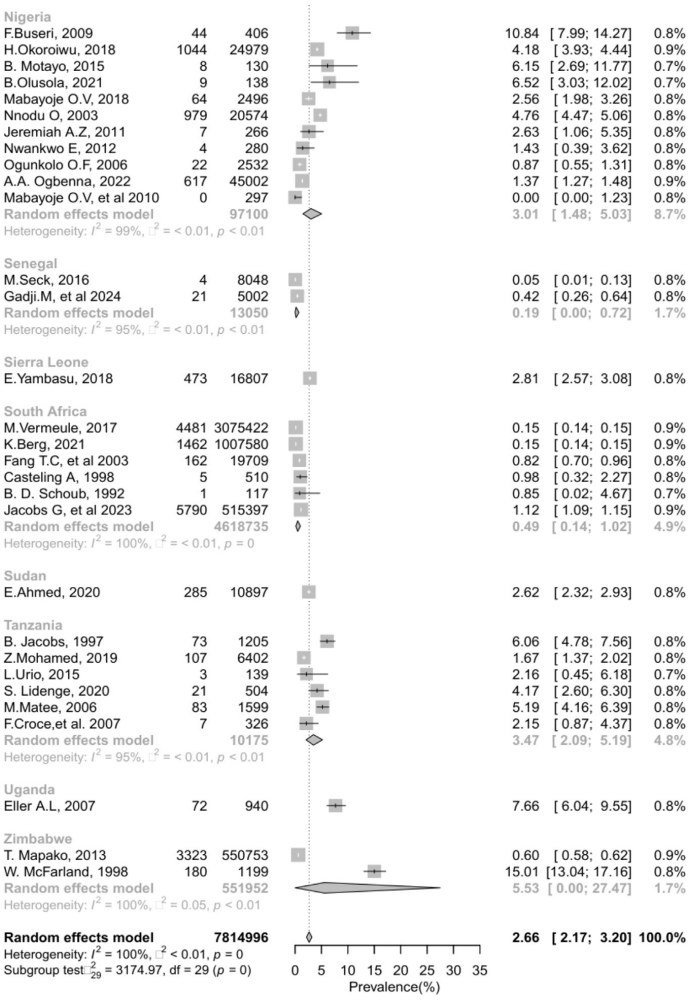
Seroprevalence of human immunodeficiency virus

We found that the pooled seroprevalence of HIV among blood donors in Africa was 2.66% (95% CI: 2.17–3.20%; with I^2 = 99.80%) (See the forest plot in Fig. 2).

In the subgroup analysis, we found statistical differences in the seroprevalence of HIV among blood donors in Africa according to the study country (p-value <0.01), African region (p-value <0.01), and year of study publication (p-value <0.01) (Figs. 2 and 3, and Table 2).

Regarding the seroprevalence of HIV by African regions, we found that the Central region had the highest prevalence of HIV at 3.28% (95% CI: 2.57%–4.06%), followed by the Eastern region with 3.21% (95% CI: 2.12%–4.52%), and by the Western Africa region with 2.66% (95% CI: 1.93%–3.49%). The lowest prevalence was observed in the Northern African region with 0.57% (95% CI: 0.00%–2.10%) and in the Southern with 0.45% (95% CI: 0.16%–0.86%) (See Fig. 2 and Table 2).

We found high heterogeneity among the pooled studies (Cochran Q test p-value <0.001 and I^2 = 99.80%). In the meta-regression analysis, we observed that the heterogeneity was moderated by the year of study publication (p-value <0.01), African region (p-value <0.01), and the country where the study was performed (p-value <0.01) (See Table 3). We found an inverse relationship and correlation between the year of study publication and the prevalence of HIV among blood donors (r = –0.004; 95% CI: –0.006 to –0.003). Recently published studies presented lower seroprevalence of HIV than earlier published studies (See Table 2 and Fig. 4).



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We did not find a statistically significant variation in the seroprevalence of HIV by the risk of bias (p-value = 0.83), study location (p-value = 0.14), setting (p-value <0.93), and type of blood donor (p-value = 0.39), age (p-value = 0.38) and proportion of male (p-value = 0.08).

Regarding the risk of publication bias, the funnel plot was not symmetrical, and the Egger regression test was statistically significant (p-value <0.01), meaning that there is some evidence of the presence of publication bias (See Fig. 5). However, this should be pondered with caution because we have large and severe heterogeneity.

Discussion

Our study shows that the pooled prevalence of HIV among blood donors in Africa is 2.66%, which is higher compared to 0.31% in China,[81] 0.06% in Pakistan,[82] 0.004% in Iran,[83] 0.32% in India[84] and 2.0% in previous systematic reviews conducted in the Southern

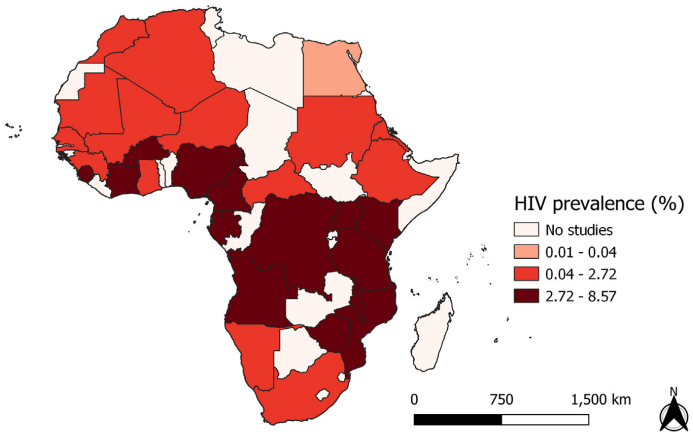

Fig. 3: **Map of the seroprevalence of HIV among blood donors in Africa.**

African Development Community.[9] The higher prevalence in Africa compared with other continents may be due to the higher prevalence of HIV in the general population, overreliance on family replacement and remunerated blood donors, and lower coverage of HIV testing services in the general population.[85–87] This high prevalence of HIV among blood donors in Africa is worrisome as the risk of transfused transmitted infection is higher in settings with higher prevalence among blood donors. Moreover, the risk of acquiring HIV infection remains higher in low-income countries, and it was estimated to be around one infection in 1000 donations in the Sub-Saharan Africa region.[88] Another reason for the high seroprevalence of HIV that we found in our study may be because the included blood donors' population was young, with an average age of 28 years old. This population is known as being a high-risk population for HIV.[89]

In our study, we found that the prevalence of HIV among blood donors is not homogeneous across the continent. Higher prevalence was observed in Central Africa (3.28%), Eastern (3.21%), and the Western (2.66%) African region. In contrast, lower prevalences were observed in the Northern (0.57%) and Southern African regions (0.45%). The heterogeneity in the prevalence of HIV among blood donors across the African continent may be explained by the existing differences in the prevalence of HIV in the general population across different countries and regions, differences in access to and quality of screening tools, lifestyle, and the social and demographic profile of each country.[9,90,91]

Moderator variables	Category	Number of studies	Prevalence % (95% CI)	I^2 (%)	*p*-value
Africa region	Western	41	2.66 (1.93; 3.49)	99.00	<0.01
	Eastern	40	3.21 (2.12; 4.52)	99.50	
	Central	28	3.28 (2.57; 4.06)	97.20	
	Southern	7	0.45 (0.16; 0.86)	99.90	
	Northern	6	0.57 (0.00; 2.10)	99.40	
Year of publication	1990–2009	31	5.44 (4.02; 7.07)	98.70	<0.01
	2010–2024	91	1.95 (1.55; 2.40)	99.40	

I^2, Heterogeneity; *p*-value: significance test of subgroup differences.

Table 2: **Sub-group analysis of the pooled prevalence of HIV estimation in African blood donors by region (1990–2024).**

Variables	Moderators test p-value	R^2 (%)
Year of publication	<0.01	15.08
African region	<0.01	10.58
Country	<0.01	20.35
Risk of bias	0.83	0.00
Location	0.14	0.92
Setting	0.93	0.00
Type of Bloody donors	0.39	0.00
Age	0.38	0.00
Proportion of male	0.08	1.81

R^2: The amount of heterogeneity accounted for.

Table 3: **Moderators of heterogeneity on the seroprevalence of HIV in blood donors in Africa.**

We found an inverse relationship between the prevalence of HIV-positive blood donors in Africa and the year of the study publication. The prevalence of HIV decreased as the years of study publication increased, meaning that recently published studies tended to present lower seroprevalence of HIV compared with earlier published studies. These findings agree with studies from the United States of America[92] and Iran,[91] which show a decreasing trend in HIV prevalence among blood donors over time. Additionally, the reduction of HIV among blood donors is in line with what has been happening in the world regarding the prevalence of HIV in general and specific population groups.[93,94] Different reasons have been pointed out in the literature for the decline of HIV prevalence in the world, such as increased access to HIV testing and treatment and increased population awareness and behavioral changes.[93,94] Moreover, the reduction of HIV prevalence among blood donors may be due to the improvement in blood donors' selection, testing, and laboratory quality assurance systems. Additionally, this reduction of the seroprevalence of HIV among blood donors over the year may be attributed to the enhanced financial mechanisms aimed at supporting African countries in strengthening health programs to combat the HIV epidemic, such as the President's Emergency Plan for AIDS Relief (PEPFAR) funds and the establishment of the Global Fund.[4]

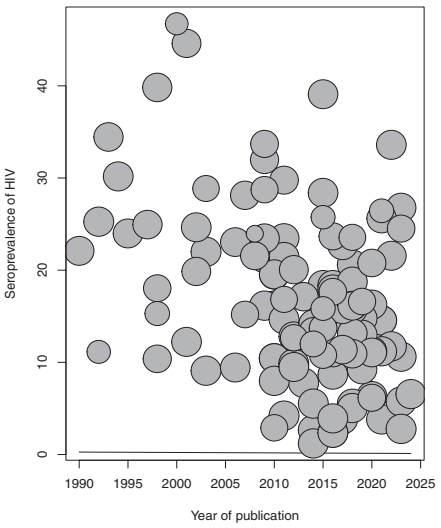

Fig. 4: **Bubble plot meta-regression of seroprevalence of HIV among blood donors in Africa and year of study publication.**

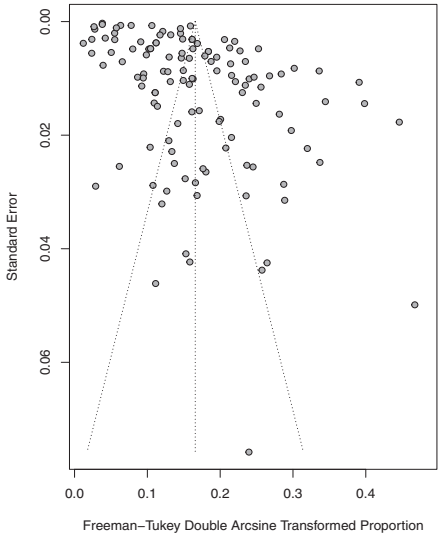

Fig. 5: **Funnel plot of the seroprevalence of HIV in African blood donors from 1990 to 2024.**

Our systematic review has some limitations. The pooled seroprevalence of HIV among blood donors that we found cannot be generalized to the whole of Africa as 24 (44%) of the African countries did not have any study on the topic. Some regions, such as Africa's Western, Eastern, and Central regions, were overrepresented, and the Southern and Northern regions were underrepresented. We found high heterogeneity among the included studies (I^2 = 99.8%). Furthermore, funnel plot analysis and the Egger regression test detected publication bias. Despite augmenting our search strategies to mitigate this issue, the persistent indication of publication bias in the funnel plot implies that our study may still be vulnerable to biases originating from the selective publication of positive results. Another limitation of the

study is that the sampling in each included study might not be representative of the general population in each country. Therefore, further studies are needed, particularly concerning underrepresented African countries, to complement our findings and to have a good overview of the seroprevalence of HIV in Africa among blood donors.

Despite the above limitations, this study has strengths. To the best of our knowledge, this is the first systematic review and meta-analysis synthesizing the seroprevalence of HIV among blood donors in Africa and investigating the reasons for the variability in the prevalence of HIV across Africa. Addressing regional differences in the seroprevalence of HIV among blood donors can further aid policymakers in tailoring interventions to specific contexts, ensuring a more effective and regionally targeted response to the persistent challenge of HIV transmission through blood transfusions in Africa.

Conclusion

Despite the declining trends, the prevalence of HIV among blood donors remains high in Africa, and there is high heterogeneity across the continent. Therefore, there is a need to step up and improve clinical diagnosis, strict selections of blood donors, screening methods, and health policies to ensure blood transfusion safety.

Registration and protocol

This systematic review and meta-analysis followed the recommendations of The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA Statement Guideline updated in 2020).[95] The study protocol was registered in the PROSPERO with the number CRD42023395616.

Contributors

Angelina Edna Quintas (AEQ): Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing-original draft; Writing-review & editing.

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Data sharing statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of interests

The authors declare that they have no competing interests.

Acknowledgements

The authors want to acknowledge the Department of Community Medicine, Information and Decision in Health of the University of Porto and the Center for Health Technology and Services Research to conduct this systematic review and meta-analysis. We are grateful to the studies' authors included in this systematic review and Doctor Milaydis Sosa Napolskij, who proofread the manuscript's text.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ebiom.2024.105210.

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Supplementary materials

Table S1: Research query

Appendix
-Table S2: Study selection. Criteria for selection of Identification, Screening, Eligibility and included studies.

Appendix
Table S3. African countries covered in this Systematic Review and Meta-analysis.

Appendix
Table S4. African countries that we did not find (Not covered) in the Systematic Review and Meta-analysis.

Supplementary materials

Table S1: Research query

Search	Query
#12	Search: **#9 OR #4 AND #5 OR #6 AND #7**
#11	Search: **#9 AND #10**
#10	Search: **#4 OR #5 OR #6 OR #7**
#9	Search: **#8 AND #3**
#8	Search: **#1 AND #2**
#7	Search: **((Syphilis OR Lues))**
#6	Search: **((Hepaciviruses OR (Hepatitis C Virus OR Hepatitis C viruses) OR (Hepatitis C-Like Virus OR Hepatitis C-Like Viruses))**
#5	Search: **((Hepatitis B virus OR Hepatitis B viruses) OR (Dane Particle OR Particle Dane) OR (Hepatitis Virus OR Homologous Serum))**
#4	Search: **((HIV OR Human Immunodeficiency Virus OR Human Immunodeficiency Viruses) OR (AIDS Virus OR AIDS Viruses) OR (Acquired Immune Deficiency Syndrome Virus OR Acquired Immunodeficiency Syndrome Virus) OR (Human T Lymphotropic Virus Type III OR Human T-Lymphotropic Virus Type III) OR (Lymphadenopathy-Associated Virus OR Lymphadenopathy Associated Virus OR Lymphadenopathy-Associated Viruses) OR (HTLV-III OR LAV-HTLV-III))**
#3	Search: **Algeria OR Angola OR ((Benin OR (Republic of Benin) OR Dahomey)) OR (Botswana OR Bechuanaland OR Kalahari) OR ((Burkina Faso OR (Upper Volta) OR (Burkina Fasso)) OR ((Burundi OR (Republic of Burundi) OR Urundi)) OR ((Cabo Verde) OR (Republic of Cape Verde) OR (Cape Verde)) OR ((Cameroon OR (Republic of Cameron) OR (United Republic of Cameroon) OR Cameroons)) OR ((Central African Republic) OR Ubangi-Shari) OR Chad OR ((Comoros OR (Iles Comores) OR (Comoro Islands) OR Mayotte)) OR ((Democratic Republic of Congo) OR Congo OR (Kinshasa) OR Zaire OR (Belgian Congo) OR Katanga)) OR ((Republic of Congo OR Republic of the Congo OR Congo (Brazzaville)) OR ((Cote d'Ivoire OR (Ivory Coast) OR (Republic of Cote diIvoire)) OR ((Djibouti OR (Republic of Djibouti) OR (French Somaliland)) OR ((Egypt OR (Arab Republic of Egypt) OR (United Arab Republic)) OR ((Equatorial Guinea OR (Republic of Equatorial Guinea)**

Search	Query
	OR (Spanish Guinea) OR (Guinea Spanish) OR (Rio Muni)) OR Eritrea OR (Eswatini OR Swaziland) OR ((Ethiopia OR (Federal Democratic Republic of Ethiopia)) OR ((Gabon OR (Gabonese Republic)) OR ((Gambia OR (Republic of the Gambia)) OR ((Ghana OR (Republic of Ghana) OR (Gold Coast)) OR ((Guinea OR (Republic of Guinea) OR (French Guinea)) OR ((Guinea-Bissau OR (Republic of Guinea-Bissau) OR (Portuguese Guinea)) OR ((Kenya OR (Republic of Kenya)) OR ((Lesotho OR Basutoland OR (Kingdom of Lesotho)) OR ((Liberia OR (Republic of Liberia)) OR Libya OR ((Madagascar OR (Malagasy Republic)) OR ((Malawi OR (Republic of Malawi) OR Nyasaland) OR ((Mali OR (Republic of Mali)) OR Mauritania OR ((Mauritius OR (Agalega Islands)) OR (Morocco OR Ifni) OR ((Mozambique OR (Republic of Mozambique) OR Mosambique OR Mocambique OR Moçambique OR (Portuguese East Africa)) OR ((Namibia OR (Southwest Africa) OR (Republic of Namibia) OR (South West Africa)) OR ((Niger OR (Republic of Niger)) OR ((Nigeria OR (Federal Republic of Nigeria)) OR ((Rwanda OR (Republic of Rwanda)) OR (Sao Tome and Principe) OR ((Senegal OR (Republic of Senegal)) OR Seychelles OR ((Sierra Leone) OR (Republic of Sierra Leone)) OR Somalia OR ((South Africa) OR (Union of South Africa) OR (Republic of South Africa)) OR (South Sudan) OR ((Sudan OR (Republic of the Sudan)) OR ((Tanzania OR (United Republic of Tanzania) OR Zanzibar OR Tanganyika)) OR ((Togo OR (Togolese Republic)) OR Tunisia OR ((Uganda OR (Republic of Uganda)) OR ((Zambia OR (Northern Rhodesia) OR (Republic of Zambia)) OR ((Zimbabwe OR (Zimbabwe Rhodesia) OR (Southern Rhodesia) OR (Republic of Zimbabwe))
#2	Search: ((Prevalence OR Prevalences) OR (Seroprevalence OR Seroprevalences) OR (Seroepidemiologic OR Seroepidemiological))
#1	Search: Blood AND ((Donor OR Donors) OR (Donation OR Donations))

Appendix

-Table S2: Study selection. Criteria for selection of Identification, Screening, Eligibility and included studies.

	Records identified	**Records (N)**	**Total**
Identification	**Through database searching:** - Scopus - Web-Science - MEDLINE/Pubmed	 2273 651 1359	 4283
	Through other sources: - WHO database HINARI - Cochrane Collaboration - Clinical of Trials.gov - Global Index Medicus	 31 43 5 42	 121
Screening	Record screened based on title and/or abstract	4404	4404
	Records after duplicates were removed	3904	3904
	Records screened	3904	3904
Eligibility	Records excluded - Clearly irrelevant after reviewing the title and abstract	 3602	 3602
	Full-text articles assessed for eligibility	**302**	**302**
	Full-text articles excluded with reasons	**180**	**180**
	- Systematic Reviews - Not relevant data - Not found the full text - Included population already positive for the serological marker of blood transfusional infection - In children - Pregnant women - Prenatal Care HIV-1 infected individuals	43 18 5 11 9 14 3 4 73	

	Excluded because did not study the prevalence of HIV in African blood donors		
Included	Studies included in qualitative and quantitative synthesis for estimations of Human Immunodeficiency Virus	122	122

Appendix

Table S3. African countries covered in this Systematic Review and Meta-analysis.

Region Sub-regions in Africa	Study Country/Territory
Central Africa (Middle Africa)	Angola
	Cameroon
	Centre African Republic
	Democratic Republic of Congo
	Equatorial Guinea
	Gabon
Western Africa	Burkina Faso
	Côte d'Ivoire (Ivory Coast)
	Ghana
	Guinea
	Mali
	Mauritania
	Niger
	Nigeria
	Senegal
	Sierra Leone
Northern Africa	Algeria
	Egypt
	Morocco
	Sudan
Eastern Africa	Eritrea
	Ethiopia
	Kenya
	Malawi
	Mozambique
	Tanzania
	Uganda
	Zimbabwe
Southern Africa	Namibia
	South Africa

Appendix

Table S4. African countries that we did not find (Not covered) in the Systematic Review and Meta-analysis.

Region Sub-regions in Africa	Study Country/Territory
Central Africa (Middle Africa)	Chad
	Republic of Congo
	São Tomé and Príncipe
Western Africa	Benin
	Cape Verde
	The Gambia
	Guinea-Bissau
	Liberia
	Togo
Northern Africa	Ceuta
	Libya
	Tunisia
Eastern Africa	Burundi
	Comoros
	Djibouti
	Madagascar
	Mauritius
	Rwanda
	Somalia
	South Sudan
	Zambia
Southern Africa	Botswana
	Swaziland
	Lesotho

PUBLICAÇÃO 5

Seroprevalence of Serologic Markers of Syphilis in Blood Donors in African Countries: A Systematic Review and Meta-analysis. ***Angelina Edna Quintas***, Nelson Cuboia, Lemuel Cordeiro, António Sarmento, Luís Azevedo

(Submetido à revista *BMC Public Health* em 25/04/2025, aguarda decisão final dos editores após ser submetidos ao processo de revisão pelos pares)

Seroprevalence of Syphilis in Blood Donors in African Countries: A Systematic Review and Meta-analysis.

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Abstract

Background: Transfusion-transmitted infections remain a significant global public health concern in Africa, with syphilis posing a persistent challenge. However, there is limited comprehensive evidence on the seroprevalence of syphilis among blood donors in Africa. This study aimed to synthesize the evidence about seroprevalence of syphilis among blood donors across African countries at both regional and continental levels.

Methods: This systematic review and meta-analysis included studies reporting the seroprevalence of syphilis among African blood donors aged 16 - 65 years, published from inception through March 1st, 2024. Relevant studies were identified through comprehensive searches in PubMed, SCOPUS, Web of Science, WHO-HINARI, Cochrane Library, Global Index Medicus, and ClinicalTrials.gov and supplemented by hand-searching references. The pooled seroprevalence was estimated using random-effects model. Heterogeneity was assessed using Cochran's Q test and I^2 statistics, and subgroup and sensitivity analyses were performed. The risk of bias was evaluated using SeroTracker-RoB.

Results: Eighty-one studies comprising 3,812,314 blood donors met the inclusion criteria. The highest proportion of studies originated from Western Africa (n = 29, 35.8%) and Eastern Africa (n= 27, 33.3%), followed by Central Africa (n= 18, 22.2%), Northern Africa (n= 5, 6.2%), and Southern Africa (n= 2, 2.5%). The overall pooled seroprevalence of syphilis was 2.47% (95% CI [Confidence Interval]: 1.81–3.24; I^2=100%, p< 0.01). Meta-regression

indicated that heterogeneity was explained by country, risk of bias, and year of publication. Prevalence was highest in Central Africa (4.57%, 95% CI: 2.5–7.3%), followed by Western Africa (2.37%, 95% CI: 1.5–3.4%) and Eastern Africa (2.12%, 95% CI: 1.1–3.4%), with lower prevalence in Northern (0.65%, 95% CI: 0.0–2.6%) and Southern Africa (0.20%, 95% CI: 0.1–0.4%). Prevalence significantly decreased as the year of study publication increased (r=-0.0045, 95% CI: -0.0078 to -0.0012, p-value < 0.05).

Conclusion: Syphilis seroprevalence among blood donors in Africa remains significant, particularly in Central Africa, and varies by region, study year, and risk of bias. Over the past two decades, a decline in prevalence underscores the impact of improved screening and interventions. Enhanced syphilis screening and treatment are crucial for preventing transfusion-transmitted infections and ensuring blood safety across Africa.

Systematic review protocol registration: PROSPERO CRD42023395616

Keywords: Blood Donors; Seroprevalence; Serologic Tests; Syphilis; African Countries.

Background

Syphilis, caused by the anaerobic spirochete *Treponema pallidum* subspecies *pallidum*, is a significant public health concern, and it has a complex disease course divided into distinct stages[1]. While primarily transmitted through sexual contact via mucosal inoculation, syphilis can also be transmitted through blood transfusion, posing a risk despite its relatively low probability in modern medical settings [2, 3]. Therefore, the World Health Organization (WHO) recommends screening blood and blood products for syphilis before transfusion[4].

In the 1950s, syphilis was relatively rare, but its prevalence began to rise in the 1980s, particularly within communities of men who have sex with men [5].

Globally, more than 1 million sexually transmitted infections (STIs) are acquired daily[6]. In 2020, the WHO estimated 374 million new infections with one of four major STIs: chlamydia

(129 million), gonorrhea (82 million), syphilis (7.1 million), and trichomoniasis (156 million) [6].

The higher prevalence of syphilis occurs in low-income countries where it remains endemic [7]. To enhance the safety of blood transfusions, the WHO has established a universal screening protocol for *Treponema pallidum*, aiming to reduce the risk of transfusion-transmitted infections[8]

Rapid diagnostic tests (RDTs) have become widely adopted in developing countries, offering cost-effective and accessible tools to enhance blood safety [9]. Despite these efforts, blood donations across many parts of Africa still require rigorous screening to safeguard recipients [10].

Although blood donor screening programs are well established in Africa, there is a limited number of systematic reviews assessing the seroprevalence of syphilis among blood donors across the continent. The only systematic review identified in the literature was restricted to the southern region of Africa and reported a seroprevalence of 2.0%[11]. The same systematic review included only studies published between 2011 and 2021[11]. These data highlight the critical gap in comprehensive assessments at the continental level, leaving significant uncertainty regarding regional variations and trends in syphilis prevalence among blood donors. Therefore, this study aimed to systematically synthesize the available evidence on the seroprevalence of syphilis among blood donors in Africa, addressing the gaps in understanding regional variability and trends. By identifying and analyzing differences in syphilis prevalence estimates, this research provides critical insights to strengthen blood safety policies, enhance screening protocols, and support the broader goal of reducing syphilis transmission in Africa.

Methods

Study design

This systematic review and meta-analysis study was based on the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA Statement Guideline updated in 2020) [12]. The study protocol was registered in PROSPERO with the number CRD42023395616.

Study selection and search strategy

We included primary studies published in any language from inception until March 1st, 2024 that had extractable data on the seroprevalence of syphilis among blood donors in Africa and with the age range from 16 to 65 years old. We excluded all studies conducted among populations residing outside Africa, studies not performed on humans, case series, reviews, comments editorials, and studies with duplicate data. All relevant articles were searched in PubMed/Medline, SCOPUS, Web of Science, WHO research database-HINARI, Cochrane database library, Global Index Medicus and Clinical of Trials.gov electronic databases, and through hand searching in included references. The search query is in the supplementary materials Table 1.

Two reviewers (AEQ, NC) conducted the selection process independently, and discrepancies were resolved by a third reviewer (LA). This systematic review and meta-analysis is part of a more extensive study assessing the seroprevalence rates of serologic markers for Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Human Immunodeficiency Virus (HIV), and syphilis among blood donors in African countries. Due to the extensive volume of results, we divided the findings into four studies, each focusing on a specific transfusion-transmitted infection.

Data extraction

Two reviewers (AEQ, NC) extracted the data independently using a data extraction form created for this study, and discrepancies were resolved by a third reviewer (LA). For each included study, the following information was extracted: author's name, year of publication, date of participant enrollment, study design, country, and African region where the study was

conducted, total number of participants, total number of blood donors tested for syphilis (*Treponema pallidum* or VDRL positive), age and sex of the study participants, type of blood donors (VNRBD - Voluntary Non-Remunerated Blood Donors, RD - Replacement or Paid Donors, and FD - Family Donors), and the methods used for syphilis screening and diagnosis. This data was stored in a Microsoft Excel 2021 spreadsheet (Microsoft Corporation, Redmond, Washington, USA)

Quality of study assessment

The risk of bias in the included studies was assessed independently by two reviewers (AEQ, NC) using the SeroTracker-RoB tool: a decision rule-based algorithm for reproducible risk of bias assessment in seroprevalence studies[13]. Any discrepancies or persistent disagreements were resolved by a third reviewer (LA).

The studies were classified as having low, moderate, or high risk of bias. The SeroTracker-RoB tool is derived from the Joanna Briggs Institute Checklist for Prevalence Studies and includes nine questions to assess the risk of bias. Each question could be answered as "Yes," "No," or "Unclear," depending on the information provided in the study. The nine questions are: a) Was the sample frame appropriate to address the target population? b)Were study participants recruited in an appropriate way? c) Was the sample size adequate? d) Was the data analysis conducted with sufficient coverage of the identified sample? e) Were valid methods used for the identification of the condition? f) Was the condition measured in a standard, reliable way for all participants? g) Was there an appropriate adjustment for test characteristics? h) Was the response rate adequate, and if not, was the low response rate unlikely to introduce bias? Finally, the overall risk of bias (low, moderate, high, or unclear) was assessed based on the responses to these nine questions.

147

148 **Data analysis**

149 We used R software version 4.3.2 (2023-10-31) with the **meta** package for a meta-analysis of
150 proportion[14]. The proportion of blood donors who tested positive for syphilis among all
151 blood donors was estimated as our effect measure and meta-analyzed. We applied the
152 DerSimonian-Laird random-effects model to estimate the pooled seroprevalence of syphilis
153 among blood donors in Africa. Proportions were calculated using the Freeman-Tukey double
154 arcsine transformation (FTT) [15], and findings were presented with 95% confidence
155 intervals.

156 To assess the presence and magnitude of heterogeneity, we conducted Cochran's Q test and
157 calculated the I^2 statistic [16], which indicates the percentage of total variability attributable to
158 true heterogeneity, i.e., variability between studies. We performed subgroup and sensitivity
159 analyses to explore the sources of heterogeneity. In the subgroup analysis, studies were
160 stratified by country, African region, and year of publication. The years of publication were
161 categorized into three subgroups (before 2000, 2001–2010, and 2011–2024). This cutoff was
162 determined based on the distribution of studies across time.

163 To identify moderators of heterogeneity, temporal trends, and regional differences, we
164 performed a meta-regression analysis using the following variables: year of publication,
165 African region (Western, Northern, Eastern, Central, and Southern), risk of bias, study location
166 (unicentric vs. multicentric), setting (urban vs. rural), proportion of male participants, age, type
167 of blood donors, and the country where the study was conducted. In our study, we defined a
168 study location as unicentric if it was conducted in a single center or hospital, whereas
169 multicentric referred to studies conducted in multiple centers or hospitals. The setting variable
170 indicated whether the study was conducted in an urban or rural area.

171 Publication bias was assessed graphically using a funnel plot and statistically using Egger's
172 regression test. We mapped the spatial pattern of the pooled seroprevalence estimates of

syphilis among blood donors in Africa by country. The map was created using Quantum Geographic Information System (QGIS) software[17].

Role of the funding source

This study did not receive external funding and was supported solely by institutional intramural resources.

Results

A total of 4,404 records were identified through databases and manual searches, and 500 articles were removed due to duplication. After screening the titles and abstracts, 3,904 records remained, but 3,601 were removed as they were irrelevant to our study. A total of 303 references were assessed for eligibility through full-text examination, and 222 were excluded for not meeting the inclusion criteria. Of these 222, 120 did not study the prevalence of syphilis among blood donors, 42 were systematic reviews, 18 did not have relevant data, five did not have the full text, 11 included population already positive for syphilis, nine were done among children, 14 were done in pregnant and three at Prenatal care; The references of all excluded studies by category can be found in the supplementary material. The remaining 81 studies were included in the qualitative and quantitative synthesis, involving 3,812,314 participants (see Figure 1). The references for the included studies can be found in the supplementary materials.

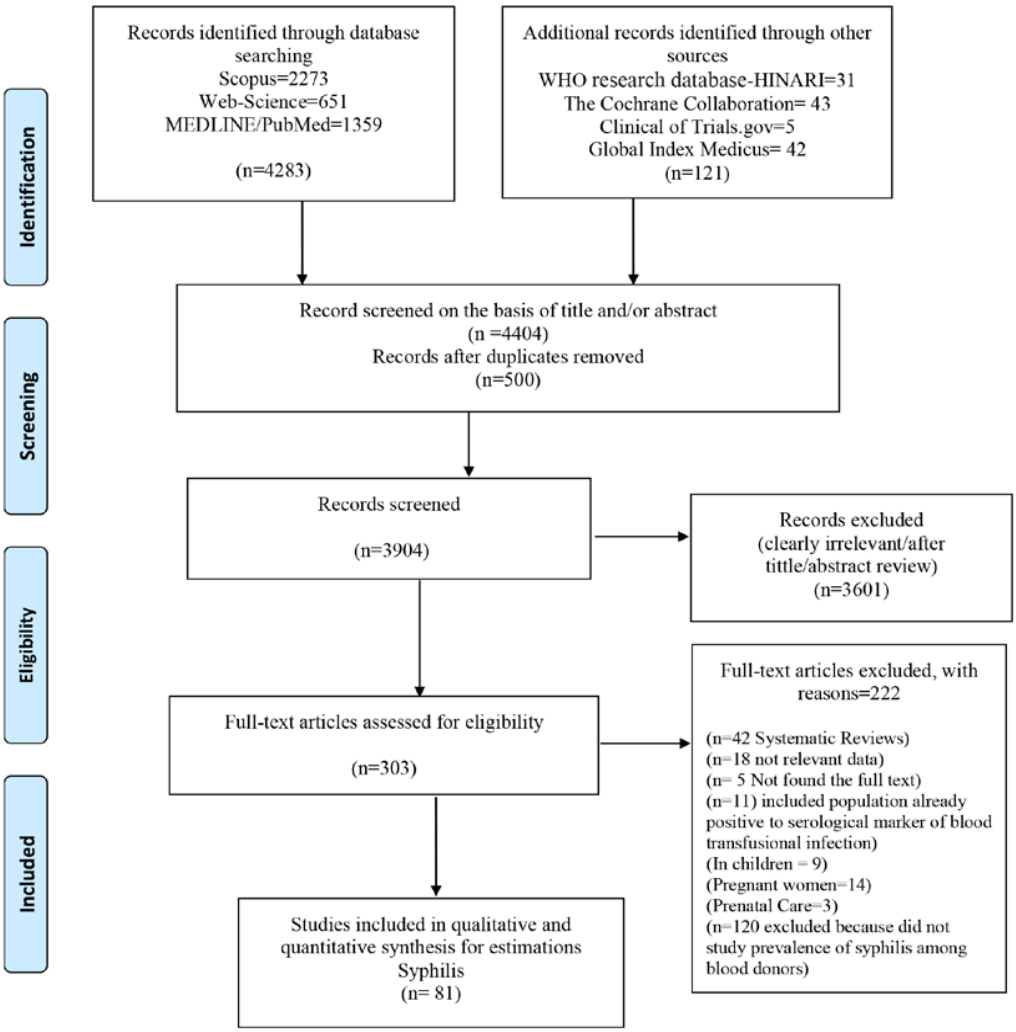

Figure 1. PRISMA flow diagram of studies reviewed, screened, and included.

Study characteristics

Table 1 shows the characteristics of all included studies in the systematic review and meta-analysis among blood donors in the African region. The 81 included studies come from 26 (48%) of the 54 African countries.

Most studies were conducted in Western Africa, with 29 (35.80%), followed by Eastern Africa with 27 (33.33%), Central Africa with 18 (22.22%), Northern Africa with 5 (6.20%), and lastly

by Southern Africa with 2 (2.47%) studies. The year of study publication ranged from 1990 to 2024, with the majority, 59 (72.84%), published after 2010. Regarding sex distribution, the study's median proportion of male participants was 83.75%. Regarding the risk of bias, most studies had a moderate risk of bias (48, 59.26%), followed by a low risk of bias (20, 24.69%), and lastly, a high risk of bias (13, 16.05%). Most studies were conducted in urban areas, with 61 (75.30%). One study from Sudan was conducted only in men, and in one study (1.23%), it was not possible to calculate the risk of bias (see Tables 1 and 2 in the supplementary material).

Table 1. Characteristics of all studies included in the systematic review and meta-analysis of TTIs

First Author's	Year of Publication	Study Design	Geographic Zone-Setting	Enrolment time	Sample Size	Total participants in Study (N)	Blood donors by sex Male N(%)	Blood donors type VNRBD (N)	Blood donors RD-Paid (N)	Family donors (FRD) (N)	Syphilis Diagnosis/Screening Methods	Syphilis's overall positivity rates N (%)	Risk of Bias
Siraj N, et al.	2018	Retrospective	Eritrea	2010-2016	60236	60236	39978(66.4))	54264	5972	-	TPHA	351 (0.6)	***Low***
Abdella S, et al.	2020	Retrospective	Ethiopia	2014-2019	554954	554954	354707(63.9)	520658	34296	-	RPR	4995(0.9)	***Low***
Buseri F, et al.	2009	Prospective	Nigeria	2007-2008	1410	406	1200(85.11)	-	-	-	TPHA	16(3.9)	***Moderate***
Okoroiwu H, et al.	2018	Both	Nigeria	2005-2016	24979	24979	24654(98.7)	137	15487	9355	Immunochromatography	786(3.2)	***Low***
Fessehaye N, et al.	2011	Retrospective	Eritrea	2006-2009	29501	29501	-	23385	6116	6116	-	145(0.5)	***Moderate***
Nzaji M, et al.	2013	Retrospective	Democratic Republic of Congo	2008	1015	1015	965(95.07)	493	522	-	RPR	2(0.2)	***Moderate***
Deressa T, et al.	2018	Retrospective	Ethiopia	2014-2017	8460	8460	5644(66.7)	-	-	-	RPR+TPHA	60(0.71)	***Moderate***
Diarra A, et al.	2009	Retrospective	Mali	2007	25543	25543	-	8094	17449	-	VDRL	84(0.3)	***Moderate***
Stokx J, et al.	2011	Retrospective	Mozambique	2009	750	750	-	-	-	-	RPR	9(1.2)	***Moderate***
Ankouane F, et al.	2016	Retrospective	Cameroon	2013	9024	9024	8453(93.7)	249	8767	-	RPR	23(0.2)	***Moderate***
Abate M, et al.	2016	Retrospective	Ethiopia	2010-2014	6827	6827	6648(97.4)	-	-	-	RPR	50(0.73)	***Moderate***
Mohammed Y, et al.	2016	Retrospective	Ethiopia	2010-2013	4224	4224	4171(98.8)	85	4139	-	RPR	4(0.09)	***Moderate***
Tessema B, et al.	2010	Retrospective	Ethiopia	2003-2007	6361	6361	5592(97.9)	-	-	-	RPR	83(1.3)	***Moderate***
Kubio C, et al.	2012	Retrospective	Ghana	2009	843	843	-	-	201	518	VDRL	22(2.61)	***Moderate***
Mavenyengwa R, et al.	2014	Retrospective	Namibia	2012	24761	24761	13054(52.7)	-	-	-	TPHA	75(0.3)	***High***
Keleta Y, et al.	2019	Retrospective	Eritrea	2014-2017	1939	1939	1710(88.2)	781	1158	1158	RPR	140(7.2)	***Moderate***
Wongjarupong N, et al.	2021	Retrospective	Burkina Faso	2009-2013	166681	166681	119437(71.7)	-	-	-	RPR	4056(2.4)	***Moderate***
Nagalo M, et al.	2011	Retrospective	Burkina Faso	2009	4520	4520	3418(75.6)	-	-	-	RPR	114(2.52)	***Low***
Nagalo M, et al.	2011	Retrospective	Burkina Faso	2009	4520	4520	3418(75.6)	-	-	-	RPR	179(3.96)	***Low***
Peliganga L, et al.	2021	Retrospective	Angola	2005-2020	57979	57979	41414(71.4)	-	-	-	RPR	2551(4.4)	***Low***
Yami A, et al.	2011	Retrospective	Ethiopia	2010	9204	6063	4802(79.2)	-	-	-	RPR	44(0.7)	***Moderate***
Bisseye C, et al.	2018	Retrospective	Gabon	2012-2017	5706	5076	4765(93.8)	-	5706	5706	RPR+TPHA	189(3.7)	***Low***
Kengne M, et al.	2018	Prospective	Cameroon	2014	265	265	242(91.3)	30	235	235	ELISA	10(3.8)	***High***
Ampofo W, et al.	2002	Retrospective	Ghana	1999	3131	808	762(94.3)	30	778	-	TPHA	109(13.5)	***High***
Ramos J, et al.	2016	Retrospective	Ethiopia	2007-2012	9493	2606	-	-	-	-	RPR	22(0.84)	***High***
Jary A, et al.	2019	Retrospective	Mali	2018	8207	8059	7157(88.8)	160	7898	-	VDRL	3(0.04)	***Moderate***
Xie D, et al.	2015	Retrospective	Equatorial Guinea	2011-2013	2937	2937	2256(76.8)	-	-	-	Immunochromatography	632(21.52)	***High***
Boushab B, et al.	2017	Retrospective	Mauritania	2010-2015	1123	1123	182(16.2)	-	-	-	RPR+TPHA	34(3)	***Moderate***
Noubiap N.J.J, et al.	2013	Retrospective	Cameroon	2011-2012	543	543	445(82)	194	-	349	TPHA	31(5.7)	***Moderate***
Wamamba D, et al.	2017	Retrospective	Kenya	2015	3690	2046	1360(66.5)	-	-	-	RPR	20(0.9)	***Low***
Heyns A, et al.	2006	Retrospective	South Africa	1999-2002	1672173	1672173	1058029(63.2)	-	-	-	TPHA	2137(0.13)	***Moderate***

Jacobs B, et al.	1997	Retrospective	Tanzania	1992	2333	1205	1074(89.1)	-	-	-	RPR+TPHA	103(8.6)	***Moderate***
Mohamed Z, et al.	2019	Retrospective	Tanzania	2016-2017	6402	6402	5383(84.1)	763	763	5634	RPR+TPHA	139(2.2)	***High***
Hussein E, et al.	2014	Retrospective	Egypt	2006-2012	308762	308762	-	195635	-	113127	syphilis antibody	409(0.13)	***Moderate***
Mogtomo M, et al.	2009	Prospective	Cameroon	1995-2004	1513	304	1171(77.4)	80	1433	1433	TPHA	7(2.30)	***High***
Nkansah C, et al.	2022	Both	Ghana	2010-2018	3306	3306	2739(82.9)	-	-	-	RPR+TPHA	271(8.2)	***Low***
Ambachew H, et al.	2018	Retrospective	Ethiopia	2016	2237	2237	-	-	-	-	ELISA	11(0.5)	***Low***
Motayo B, et al.	2015	Prospective	Nigeria	2013	130	130	126(96.9)	-	130	-	RPR+TPHA	0(0)	***Moderate***
Sarkodie F, et al.	2016	Retrospective	Ghana	2014-2015	91386 units of blood	62782	-	26180/91386	65206/91386	65206/91386	EIA+TPHA+VDRL	3371(5.4)	***High***
Seck M, et al.	2016	Prospective	Senegal	-	8219	8048	6439(80.0)	-	-	-	RPR+TPHA	27(0.34)	***Moderate***
Bisseye C, et al.	2019	Retrospective	Gabon	2004-2016	20651	20651	15633(75.7)	6068	-	14583	RPR	1142(5.5)	***Low***
Lidenge S, et al.	2020	Retrospective	Tanzania	2019	504	504	431(85.5)	-	-	-	TPHA	75(14.9)	***Low***
Yambasu E, et al.	2018	Retrospective	Sierra Leone	2016	16865	16807	13426(79.8)	1986	-	14760	TPHA	133(0.8)	***High***
Simpore A, et al.	2014	Retrospective	Burkina Faso	2011-2012	6375	6375	-	-	-	-	RPR+TPHA	183(2.9)	***Moderate***
Tagny C, et al.	2016	Retrospective	Cameroon	2011-2015	1704	1596	1313(82.3)	403	1193	1193	TPHA and Immunochromatography	18(1.1)	***Moderate***
Ahmed E, et al.	2020	Retrospective	Sudan	2017	10897	10897	10897(100) All men	10897	-	-	Immunochromatography	624(5.7)	***Moderate***
Onyango C, et al.	2018	Retrospective	Kenya	2015-2016	1215	1215	700(57.6)	-	-	-	RPR	19(1.56)	***Moderate***
Bisetegen F, et al.	2016	Retrospective	Ethiopia	2015	390	390	291(74.6)	-	-	-	ELISA	31(7.9)	***High***
Ibrahim Y, et al.	2014	Retrospective	Egypt	2010-2011	17118	17118	13918(81.3)	2101	15017	15017	TPHA	44(0.3)	***Moderate***
Matee M, et al.	2006	Retrospective	Tanzania	2005	1599	1597	1424(89.2)	474	1125	-	VDRL+TPHA	75(4.7)	***Moderate***
Assefa A, et al.	1994	Prospective	Ethiopia	1989-1993 and 1991-1993	3696	2018	3066/3696 (82.9)	-	-	-	RPR	163(8.1)	***Low***
Issa A.B, et al.	2013	Retrospective	Nigeria	2010-2011	700	350	339(96.9)	-	-	206	RDTs+TPHA	4(1.1)	***Moderate***
Rahlenbeck I S, et al	2015	Retrospective	Ethiopia	1994-1995	2186	2186	-	VNRBD	-	-	RPR	283(12.9)	***Low***
Nwankwo E, et al.	2012	Retrospective	Nigeria	2008	280	280	276(98.6)	61	62	157	TPHA	21(7.5)	***High***
El-Zayadi R.A, et al.	2008	Retrospective	Egypt	2005	760	760	636(83.7)	VNRBD	-	-	TPHA	1(0.13)	***Moderate***
Ndilu K.L, et al.	2016	Retrospective	Democratic Republic of Congo	2012-2013	372	372	252(67.7)	VNRBD	-	-	-	7(1.9)	***High***
Kania D, et al.	2009	Retrospective	Burkina Faso	2002	500	500	-	500	-	-	TPHA	8(1.6)	***Moderate***
Mbanya N.D, et al.	2003	Retrospective	Cameroon	2001	264	252	197(78.2)	VNRBD	-	-	TPHA	23(9.1)	***High***
Gudo S.E, et al.	2009	Retrospective	Mozambique	2006	2019	1535	1616/1989 (81.2)	VNRBD	-	-	RPR	15(0.98)	***Moderate***

Table 1. Characteristics of all Syphilis studies included in the systematic review and meta-analysis of TTIs among blood donors in 5 African regions.

Maida, J.M, et al.	2000	Retrospective	Malawi	1996	100	100	-	-	-	-	VDRL+RPR	4(4)	***Moderate***
Adjei A.A, et al.	2003	Retrospective	Ghana	2003	536	536	500(93.3)	VNRBD	-	-	RPR+TPPA+VDRL	40(7.5)	***Moderate***
Sarkodie F, et al.	2016	Retrospective	Ghana	2014-2015	30364	16016	-	-	-	-	RPR and VDRL	526(3.2)	***Moderate***
Malonga G.A, et al.	2022	Retrospective	Mali	2019-2020	229	229	_	-	-	-	_	5(2.2)	***Moderate***
Jager H, et al.	1990	Retrospective	Democratic Republic of Congo	1989	2237	2237	2031(90.8)	275	571	1391	TPHA	298(13.3)	
Dionne-Odom J, et al.	2016	Retrospective	Cameroon	2014	3364	3364	_	3364	-	-	RDTs	135(4.0)	**Low**
Rerambiah K.L, et al.	2014	Retrospective	Gabon	NA	775	775	552(71.2)	-	-	-	EIA+TPHA+VDRL	31(4.0)	***Moderate***
Nambei S.W, et al.	2016	Retrospective	Central African Republic	2016	551	551	8453(93.7)	-	-	-	Determine® Syphilis TP	24(4.36)	***Moderate***
Kebede E, et al.	2020	Retrospective	Ethiopia	2018	384	384	213(55.5)	384	-	-	ELISA	7(1.82)	***Moderate***
Addai-Mensah O, et al.	2015	Retrospective	Ghana	2014	400	400	356(89)	200	-	200	RDTs	15(3.75)	***Moderate***
Mayaki Z, et al.	2012	Retrospective	Niger	2010	3213	3213	2574(80.1)	2204	-	1009	RPR	15(0.47)	***Moderate***
Abebe M, et al.	2021	Retrospective	Ethiopia	2015-2019	17810	17810	12480(70.1)	-	-	-	ELISA	142(0.8)	***Low***
Simpore A, et al.	2022	Retrospective	Burkina Faso	2017-2019	63779	63779	44152(69.2)	VNRBD	-	-	RPR	1743(3.22)	***Moderate***
Mremi A, et al.	2021	Retrospective	Tanzania	2017-2019	101616	101616	85053 (83.7)	79582	22034	-	TPHA	1880(1.9%)	***Low***
Nsekuye O, et al.	2023	Retrospective	Rwanda	2015-2019	36708	36708	21091(57.5)	-	-	-	RPR	123(0.34)	***Moderate***
Quintas E.A, et al.	2023	Retrospective	Angola	2011-2016	2734	2734	2467(90.0)	66	-	2668	ELISA	436(20)	***Low***
Djoudi F, et al.	2023	Both	Algeria	2010-2019	140168	140168	111461 (79.5)	-	-	-	3rd Gen ELISA	186(0.13)	***Low***
Walama W, et al.	2023	Retrospective	Ghana	2020-2021	6085	5739	5970(98)	187	1496	4211	TPHA	393(6.8)	***Low***
Singogo E, et al	2023	Retrospective	Malawi	2015-2021	204920	204920	158508 (77.4)	VNRBD	-	-	TPHA	1188(2.1)	***Low***
Olokoba A.B, et al	2009	Retrospecive	Nigeria	2007-2008	595	595	571(96)	VNRBD	-	-	RPR	7(1.2)	***High***
Gadji M, et al.	2024	Retrospective	Senegal	2019-2021	5002	5002	3746(75.0)	2303	-	2699	TPHA	18(1.2)	***Moderate***
Ntawuyamara E, et al	2024	Retrospective	Burundi	2015-2020	1370	1370	228059 (77)	515397	-	-	TPHA	3(0.2)	***High***

Enzyme-linked immunosorbent Assay (ELISA), *gen* generation, - EIA based rapid immunochromatographic rapid kits, RDTs (rapid diagnostic tests); Real-time polymerase chain reaction (RT-PCR) assay - *Treponema pallidum* Hemagglutination Assay (TPHA) test; Venereal Disease Research Laboratory (VDRL) test, RPR (Plasmin Reagin Test); DiaSpot (cassette type), ACON (strips) and oneStep HIGHTOP (strips).

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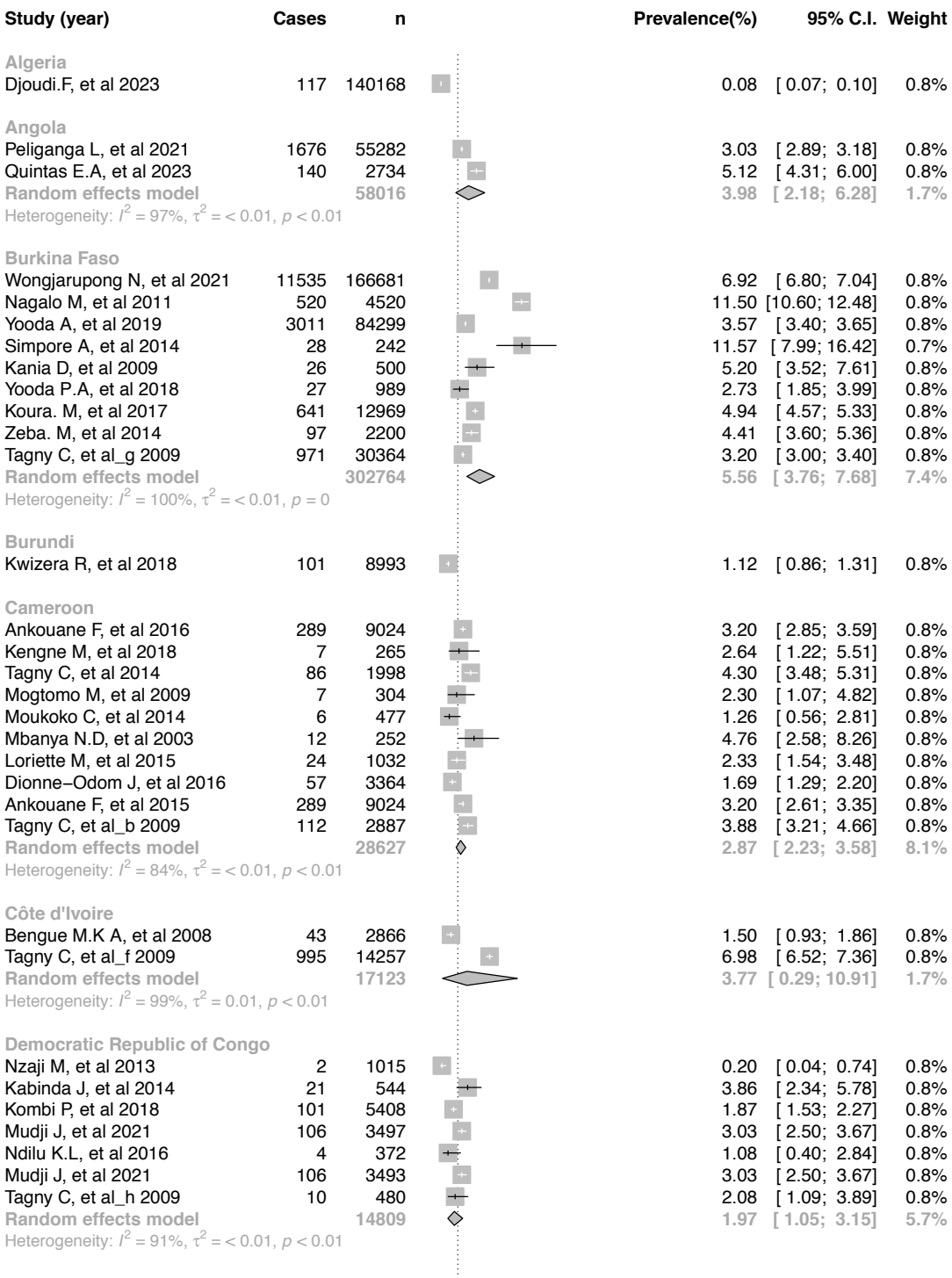
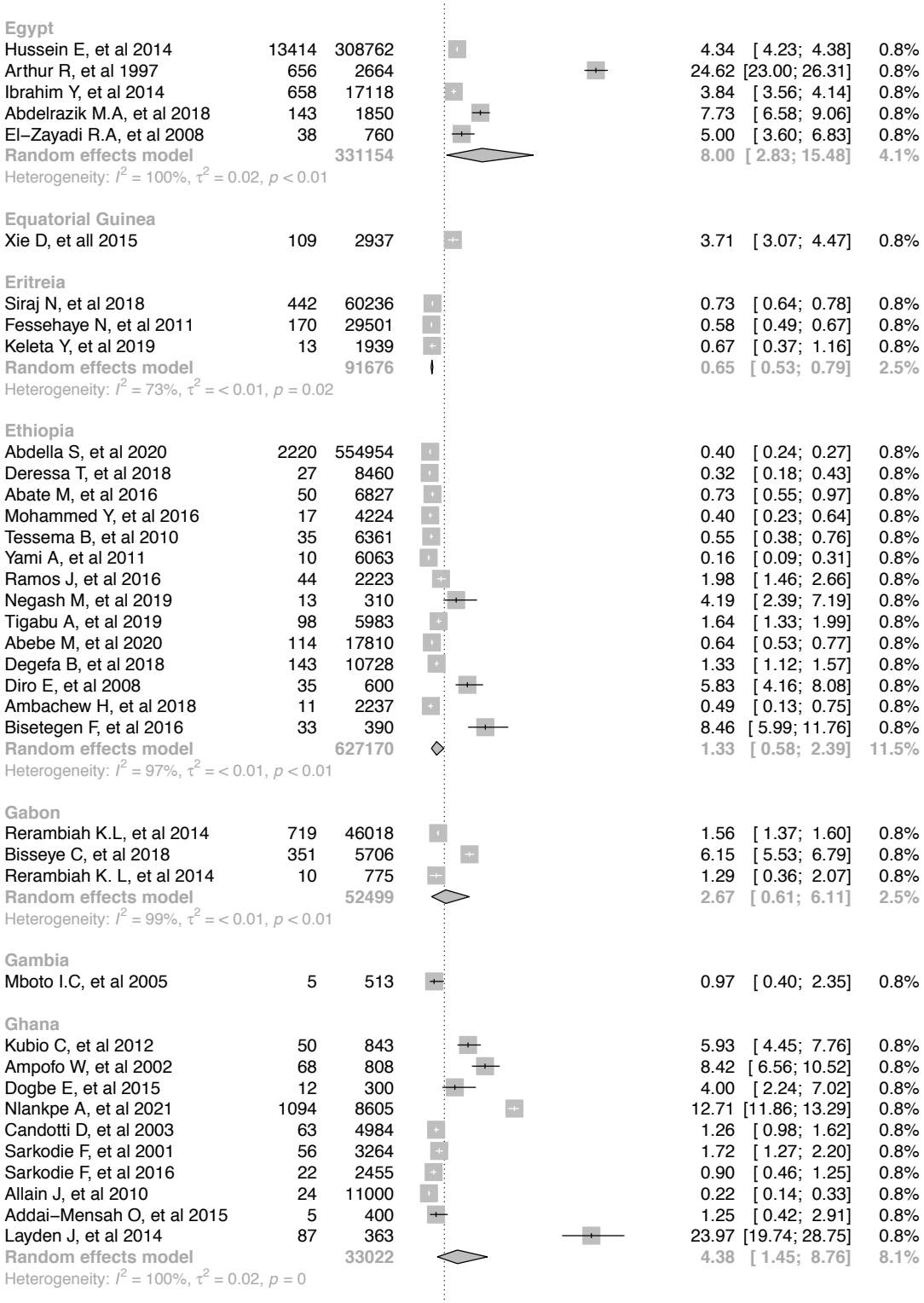
218 **Seroprevalence of Syphilis**

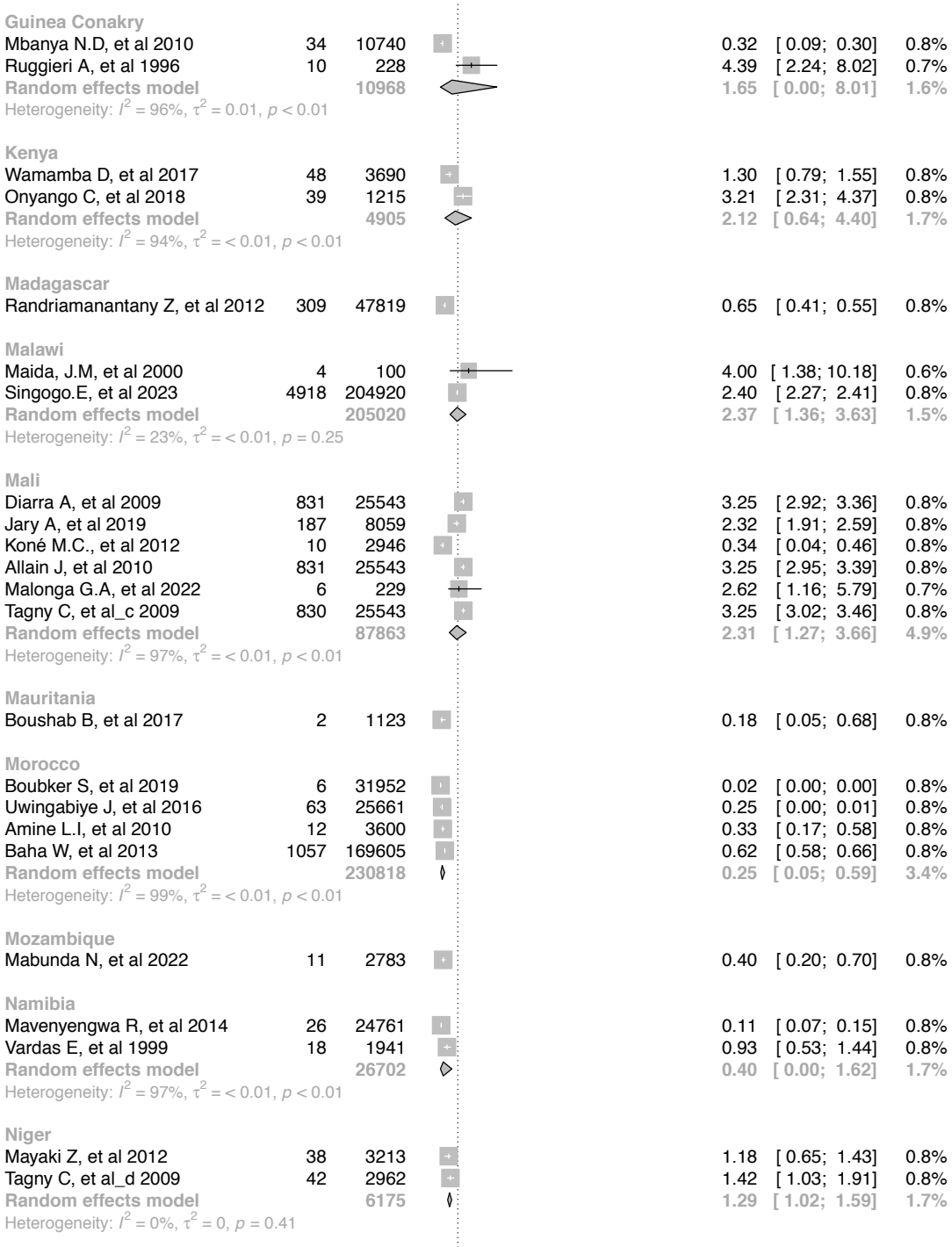
219 We found that the overall pooled seroprevalence of syphilis among blood donors in Africa was

220 2.47% (95% CI: 1.81–3.24), with high heterogeneity (I^2 = 100%) (see Figure 2 for the forest

221 plot)


Study (year) Cases n Prevalence(%) 95% C.I. Weight
Algeria
Djoudi.F, et al 2023 117 140168 0.08 [0.07; 0.10] 0.8%
Angola
Peliganga L, et al 2021 1676 55282 3.03 [2.89; 3.18] 0.8%
Quintas E.A, et al 2023 140 2734 5.12 [4.31; 6.00] 0.8%
Random effects model 58016 3.98 [2.18; 6.28] 1.7%
Heterogeneity: I^2 = 97%, τ^2 = < 0.01, p < 0.01
Burkina Faso
Wongjarupong N, et al 2021 11535 166681 6.92 [6.80; 7.04] 0.8%
Nagalo M, et al 2011 520 4520 11.50 [10.60; 12.48] 0.8%
Yooda A, et al 2019 3011 84299 3.57 [3.40; 3.65] 0.8%
Simpore A, et al 2014 28 242 11.57 [7.99; 16.42] 0.7%
Kania D, et al 2009 26 500 5.20 [3.52; 7.61] 0.8%
Yooda P.A, et al 2018 27 989 2.73 [1.85; 3.99] 0.8%
Koura. M, et al 2017 641 12969 4.94 [4.57; 5.33] 0.8%
Zeba. M, et al 2014 97 2200 4.41 [3.60; 5.36] 0.8%
Tagny C, et al_g 2009 971 30364 3.20 [3.00; 3.40] 0.8%
Random effects model 302764 5.56 [3.76; 7.68] 7.4%
Heterogeneity: I^2 = 100%, τ^2 = < 0.01, p = 0
Burundi
Kwizera R, et al 2018 101 8993 1.12 [0.86; 1.31] 0.8%
Cameroon
Ankouane F, et al 2016 289 9024 3.20 [2.85; 3.59] 0.8%
Kengne M, et al 2018 7 265 2.64 [1.22; 5.51] 0.8%
Tagny C, et al 2014 86 1998 4.30 [3.48; 5.31] 0.8%
Mogtomo M, et al 2009 7 304 2.30 [1.07; 4.82] 0.8%
Moukoko C, et al 2014 6 477 1.26 [0.56; 2.81] 0.8%
Mbanya N.D, et al 2003 12 252 4.76 [2.58; 8.26] 0.8%
Loriette M, et al 2015 24 1032 2.33 [1.54; 3.48] 0.8%
Dionne−Odom J, et al 2016 57 3364 1.69 [1.29; 2.20] 0.8%
Ankouane F, et al 2015 289 9024 3.20 [2.61; 3.35] 0.8%
Tagny C, et al_b 2009 112 2887 3.88 [3.21; 4.66] 0.8%
Random effects model 28627 2.87 [2.23; 3.58] 8.1%
Heterogeneity: I^2 = 84%, τ^2 = < 0.01, p < 0.01
Côte d'Ivoire
Bengue M.K A, et al 2008 43 2866 1.50 [0.93; 1.86] 0.8%
Tagny C, et al_f 2009 995 14257 6.98 [6.52; 7.36] 0.8%
Random effects model 17123 3.77 [0.29; 10.91] 1.7%
Heterogeneity: I^2 = 99%, τ^2 = 0.01, p < 0.01
Democratic Republic of Congo
Nzaji M, et al 2013 2 1015 0.20 [0.04; 0.74] 0.8%
Kabinda J, et al 2014 21 544 3.86 [2.34; 5.78] 0.8%
Kombi P, et al 2018 101 5408 1.87 [1.53; 2.27] 0.8%
Mudji J, et al 2021 106 3497 3.03 [2.50; 3.67] 0.8%
Ndilu K.L, et al 2016 4 372 1.08 [0.40; 2.84] 0.8%
Mudji J, et al 2021 106 3493 3.03 [2.50; 3.67] 0.8%
Tagny C, et al_h 2009 10 480 2.08 [1.09; 3.89] 0.8%
Random effects model 14809 1.97 [1.05; 3.15] 5.7%
Heterogeneity: I^2 = 91%, τ^2 = < 0.01, p < 0.01


Egypt
Hussein E, et al 2014 13414 308762 4.34 [4.23; 4.38] 0.8%
Arthur R, et al 1997 656 2664 24.62 [23.00; 26.31] 0.8%
Ibrahim Y, et al 2014 658 17118 3.84 [3.56; 4.14] 0.8%
Abdelrazik M.A, et al 2018 143 1850 7.73 [6.58; 9.06] 0.8%
El–Zayadi R.A, et al 2008 38 760 5.00 [3.60; 6.83] 0.8%
Random effects model 331154 8.00 [2.83; 15.48] 4.1%
Heterogeneity: I^2 = 100%, τ^2 = 0.02, p < 0.01
Equatorial Guinea
Xie D, et all 2015 109 2937 3.71 [3.07; 4.47] 0.8%
Eritreia
Siraj N, et al 2018 442 60236 0.73 [0.64; 0.78] 0.8%
Fessehaye N, et al 2011 170 29501 0.58 [0.49; 0.67] 0.8%
Keleta Y, et al 2019 13 1939 0.67 [0.37; 1.16] 0.8%
Random effects model 91676 0.65 [0.53; 0.79] 2.5%
Heterogeneity: I^2 = 73%, τ^2 = < 0.01, p = 0.02
Ethiopia
Abdella S, et al 2020 2220 554954 0.40 [0.24; 0.27] 0.8%
Deressa T, et al 2018 27 8460 0.32 [0.18; 0.43] 0.8%
Abate M, et al 2016 50 6827 0.73 [0.55; 0.97] 0.8%
Mohammed Y, et al 2016 17 4224 0.40 [0.23; 0.64] 0.8%
Tessema B, et al 2010 35 6361 0.55 [0.38; 0.76] 0.8%
Yami A, et al 2011 10 6063 0.16 [0.09; 0.31] 0.8%
Ramos J, et al 2016 44 2223 1.98 [1.46; 2.66] 0.8%
Negash M, et al 2019 13 310 4.19 [2.39; 7.19] 0.8%
Tigabu A, et al 2019 98 5983 1.64 [1.33; 1.99] 0.8%
Abebe M, et al 2020 114 17810 0.64 [0.53; 0.77] 0.8%
Degefa B, et al 2018 143 10728 1.33 [1.12; 1.57] 0.8%
Diro E, et al 2008 35 600 5.83 [4.16; 8.08] 0.8%
Ambachew H, et al 2018 11 2237 0.49 [0.13; 0.75] 0.8%
Bisetegen F, et al 2016 33 390 8.46 [5.99; 11.76] 0.8%
Random effects model 627170 1.33 [0.58; 2.39] 11.5%
Heterogeneity: I^2 = 97%, τ^2 = < 0.01, p < 0.01
Gabon
Rerambiah K.L, et al 2014 719 46018 1.56 [1.37; 1.60] 0.8%
Bisseye C, et al 2018 351 5706 6.15 [5.53; 6.79] 0.8%
Rerambiah K. L, et al 2014 10 775 1.29 [0.36; 2.07] 0.8%
Random effects model 52499 2.67 [0.61; 6.11] 2.5%
Heterogeneity: I^2 = 99%, τ^2 = < 0.01, p < 0.01
Gambia
Mboto I.C, et al 2005 5 513 0.97 [0.40; 2.35] 0.8%
Ghana
Kubio C, et al 2012 50 843 5.93 [4.45; 7.76] 0.8%
Ampofo W, et al 2002 68 808 8.42 [6.56; 10.52] 0.8%
Dogbe E, et al 2015 12 300 4.00 [2.24; 7.02] 0.8%
Nlankpe A, et al 2021 1094 8605 12.71 [11.86; 13.29] 0.8%
Candotti D, et al 2003 63 4984 1.26 [0.98; 1.62] 0.8%
Sarkodie F, et al 2001 56 3264 1.72 [1.27; 2.20] 0.8%
Sarkodie F, et al 2016 22 2455 0.90 [0.46; 1.25] 0.8%
Allain J, et al 2010 24 11000 0.22 [0.14; 0.33] 0.8%
Addai–Mensah O, et al 2015 5 400 1.25 [0.42; 2.91] 0.8%
Layden J, et al 2014 87 363 23.97 [19.74; 28.75] 0.8%
Random effects model 33022 4.38 [1.45; 8.76] 8.1%
Heterogeneity: I^2 = 100%, τ^2 = 0.02, p = 0


Guinea Conakry
Mbanya N.D, et al 2010 34 10740 0.32 [0.09; 0.30] 0.8%
Ruggieri A, et al 1996 10 228 4.39 [2.24; 8.02] 0.7%
Random effects model 10968 1.65 [0.00; 8.01] 1.6%
Heterogeneity: I^2 = 96%, τ^2 = 0.01, p < 0.01
Kenya
Wamamba D, et al 2017 48 3690 1.30 [0.79; 1.55] 0.8%
Onyango C, et al 2018 39 1215 3.21 [2.31; 4.37] 0.8%
Random effects model 4905 2.12 [0.64; 4.40] 1.7%
Heterogeneity: I^2 = 94%, τ^2 = < 0.01, p < 0.01
Madagascar
Randriamanantany Z, et al 2012 309 47819 0.65 [0.41; 0.55] 0.8%
Malawi
Maida, J.M, et al 2000 4 100 4.00 [1.38; 10.18] 0.6%
Singogo.E, et al 2023 4918 204920 2.40 [2.27; 2.41] 0.8%
Random effects model 205020 2.37 [1.36; 3.63] 1.5%
Heterogeneity: I^2 = 23%, τ^2 = < 0.01, p = 0.25
Mali
Diarra A, et al 2009 831 25543 3.25 [2.92; 3.36] 0.8%
Jary A, et al 2019 187 8059 2.32 [1.91; 2.59] 0.8%
Koné M.C., et al 2012 10 2946 0.34 [0.04; 0.46] 0.8%
Allain J, et al 2010 831 25543 3.25 [2.95; 3.39] 0.8%
Malonga G.A, et al 2022 6 229 2.62 [1.16; 5.79] 0.7%
Tagny C, et al_c 2009 830 25543 3.25 [3.02; 3.46] 0.8%
Random effects model 87863 2.31 [1.27; 3.66] 4.9%
Heterogeneity: I^2 = 97%, τ^2 = < 0.01, p < 0.01
Mauritania
Boushab B, et al 2017 2 1123 0.18 [0.05; 0.68] 0.8%
Morocco
Boubker S, et al 2019 6 31952 0.02 [0.00; 0.00] 0.8%
Uwingabiye J, et al 2016 63 25661 0.25 [0.00; 0.01] 0.8%
Amine L.I, et al 2010 12 3600 0.33 [0.17; 0.58] 0.8%
Baha W, et al 2013 1057 169605 0.62 [0.58; 0.66] 0.8%
Random effects model 230818 0.25 [0.05; 0.59] 3.4%
Heterogeneity: I^2 = 99%, τ^2 = < 0.01, p < 0.01
Mozambique
Mabunda N, et al 2022 11 2783 0.40 [0.20; 0.70] 0.8%
Namibia
Mavenyengwa R, et al 2014 26 24761 0.11 [0.07; 0.15] 0.8%
Vardas E, et al 1999 18 1941 0.93 [0.53; 1.44] 0.8%
Random effects model 26702 0.40 [0.00; 1.62] 1.7%
Heterogeneity: I^2 = 97%, τ^2 = < 0.01, p < 0.01
Niger
Mayaki Z, et al 2012 38 3213 1.18 [0.65; 1.43] 0.8%
Tagny C, et al_d 2009 42 2962 1.42 [1.03; 1.91] 0.8%
Random effects model 6175 1.29 [1.02; 1.59] 1.7%
Heterogeneity: I^2 = 0%, τ^2 = 0, p = 0.41

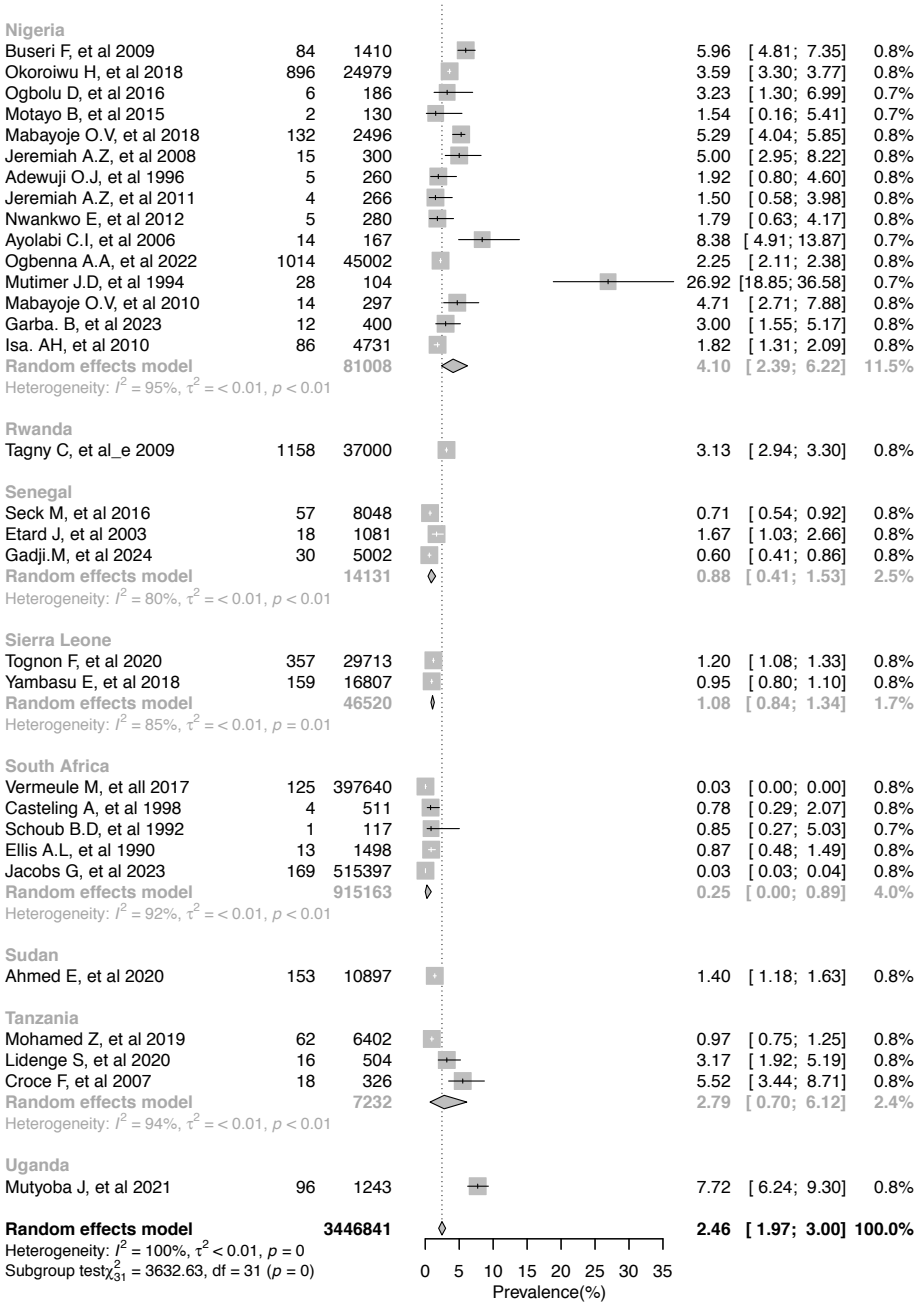
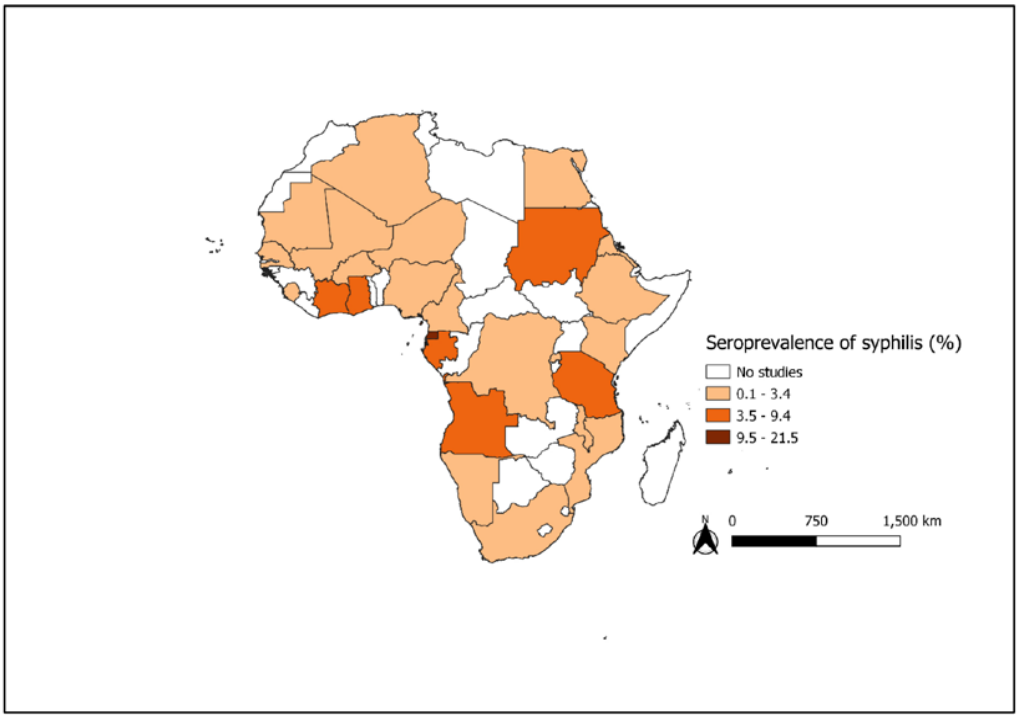


Figure 2: Forest plot of the pooled seroprevalence of Syphilis among Blood donors in Africa by country, Random-effect model: subgroup analysis by region. ES estimated Prevalence of Syphilis.

In subgroup analysis, we observed that the seroprevalence of syphilis varied substantially according to the Country (African region) p-value <0.01, year of study publication (p-value<0.01), and risk of bias (p-value<0.01) (figure 2, 3 and table 3,4).

Figure 3: Map of the seroprevalence of syphilis among blood donors in Africa.



The highest syphilis seroprevalence was found in the Central Africa region at 4.57% (95% CI: 2.45% to 7.28%), followed by the Western region at 2.38% (95% CI: 1.53% to 3.39%), the Eastern region at 2.12% (95% CI: 1.14% to 3.38%), the Northern region at 0.66% (95% CI: 0.0% to 2.56%), and lastly, the Southern Africa region with the lowest seroprevalence at 0.20% (95% CI: 0.07% to 0.41%) (see Figure 3 and Table 3).

241 **Table 3:** Sub-group analysis of the pooled prevalence of Syphilis estimation in blood donors
242 in Africa region (1990-2022).

Moderator variables	Category	N° of studies	Prevalence % (95% CI)	I^2(%)	P-value
Africa region	Central	18	4.57 (2.45;7.28)	99.5	<0.01
	Western	29	2.38 (1.53;3.39)	99.5	
	Eastern	27	2.12 (1.14;3.38)	98.9	
	Northern	5	0.66 (0.00;2.56)	99.8	
	Southern	2	0.20 (0.07;0.41)	97.3	
Year of publication	1990-2000	5	9.99(7.27;13.09)	92.6	<0.01
	2001-2010	17	2.28 (1.01;4.02)	99.6	
	2011-2024	59	2.12 (1.47; 2.93)	99.8	

243 I^2= Heterogeneity; *p*-value: significance test of subgroup differences
244
245 **Table 3**: The sub-group analysis of pooled seroprevalence of Syphilis among blood donors in
246 Africa region (1990-2024).
247 In general, we observed high heterogeneity among the pooled studies (Cochran's Q test p-value
248 < 0.001 and I^2 = 99.8%). The meta-regression analysis revealed that heterogeneity was
249 influenced by the year of study publication (p-value < 0.001), risk of bias (p-value < 0.001),
250 and the country where the study was conducted (p-value < 0.001) (see Table 4). We identified
251 an inverse correlation between the year of studies publication and syphilis prevalence among
252 blood donors (r = -0.004, 95% CI: -0.0078 to -0.0012). More recent studies generally reported
253 lower syphilis seroprevalence compared to older studies. The bubble plot in the meta-
254 regression visually demonstrated a decline in syphilis seroprevalence over the years, with a
255 notable concentration of studies published after 2010 (see Table 3 and Figure 4).

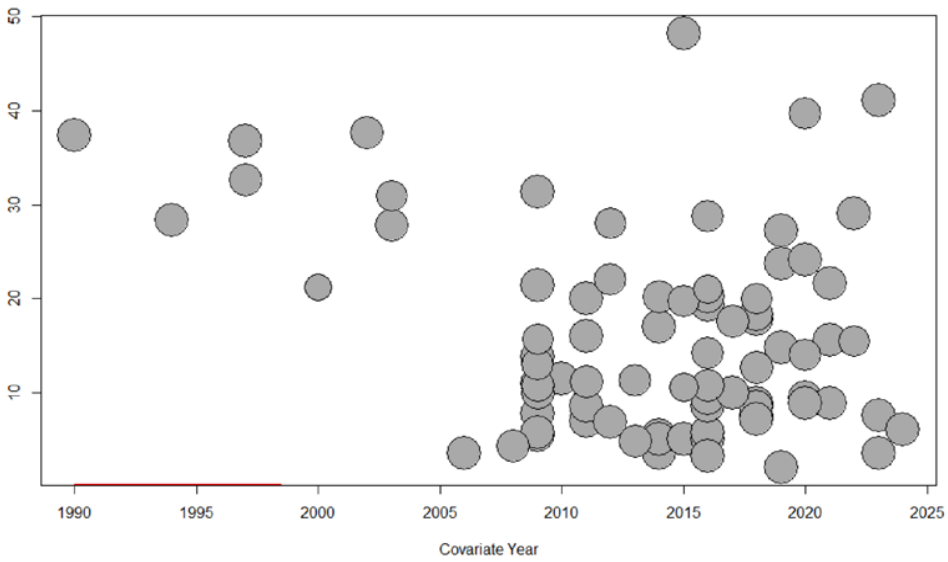


Figure 4: Bubble plot meta-regression of seroprevalence of Syphilis among blood donors in Africa and year of study publication.

Among the moderators studied, 26.84% of the heterogeneity was explained by the country where the study was conducted (p-value < 0.01), followed by the African region (9.41%, p-value < 0.02), and the year of study publication (7.27%, p-value < 0.01). The risk of bias contributed 8.11% to the heterogeneity (p-value < 0.01). However, the study location (p-value = 0.72), setting (p-value = 0.69), and blood donor type (p-value = 0.57) did not show statistically significant associations.

Table 4: Moderators of heterogeneity on the seroprevalence of Syphilis in blood donors in Africa

Variables	Moderators test p-value	R^2 (%)
Year of publication	<0.01	7.27
African region	0.02	9.41
		31.45
Country	<0.01	
Risk of bias	= 0.01	8.11

Location	0.72	0.00
Setting	0.69	0.00
Type of Bloody donors	0.57	0.00

R^2: The amount of heterogeneity accounted for.
Table 4: Moderators of heterogeneity on the seroprevalence of Syphilis in blood donors in Africa.

The visual funnel plot displayed asymmetry, and Egger's test showed a statistically significant result ($p < 0.001$), indicating the possible presence of publication bias. (See Figure 5).

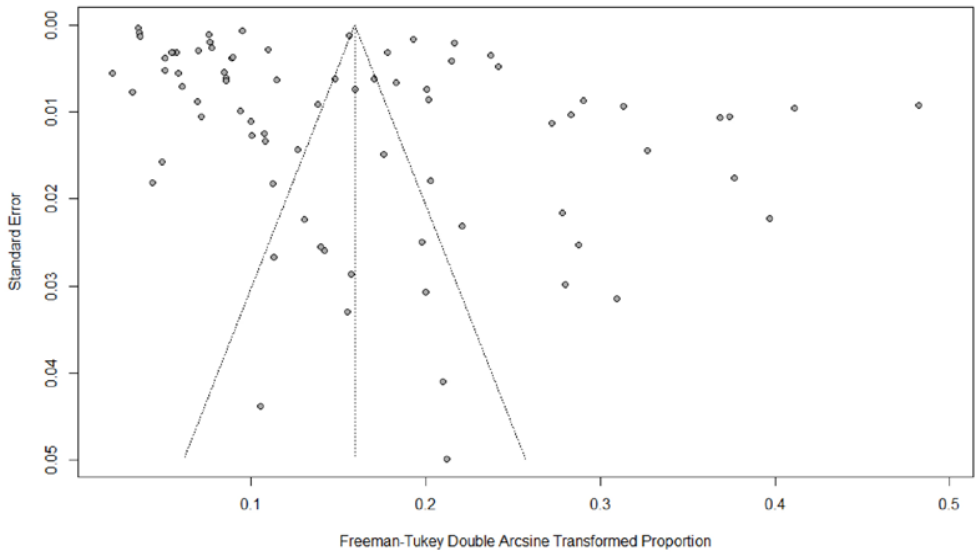


Figure 5: Funnel plot of the seroprevalence of Syphilis in blood donors in Africa region from 1990 to 2024.

Discussion:

The findings of this study provide a comprehensive assessment of syphilis seroprevalence among blood donors across Africa, revealing an overall pooled seroprevalence of 2.47% (95% CI: 1.81–3.24; $I^2 = 100\%$). Additionally, we found a higher variability across the continent and decreased prevalence over time. This prevalence underscores the public health importance of

284 syphilis as a transfusion-transmitted infection, particularly in resource-constrained settings.
285 The high level of heterogeneity observed (I^2 = 100%) reflects substantial variation across
286 studies, warranting further exploration of underlying factors influencing these differences. Our
287 pooled seroprevalence was higher than the global prevalence of syphilis among the general
288 population of 1.11%[18] and 0.33 % observed among volunteer blood donors in Jinan City in
289 China[19]. Additionally, the prevalence we found was higher than observed in Riyadh, Saudi
290 Arabia, at 0.044% [20] and 1.1% in Pakistan[21]. This difference could be attributed to the
291 variations in the prevalence of syphilis in the general population, the organization of the health
292 care system, and the level of exposure to the risk factors.
293 Subgroup analyses demonstrated significant regional variation in syphilis seroprevalence, with
294 the Central African region exhibiting the highest prevalence while the Southern African region
295 had the lowest. These findings suggest regional disparities in the burden of syphilis, potentially
296 attributable to differences in healthcare access, screening practices, and social determinants of
297 health[22]. The marked variability of the seroprevalence of syphilis across regions aligns with
298 previous systematic review and meta-analyses conducted in sub-Saharan Africa among people
299 living with and without HIV and pregnant women, which may indicate the role of
300 socioeconomic and healthcare infrastructure in influencing disease prevalence[23, 24].
301 Therefore, these findings emphasize the critical need for region-specific strategies to address
302 syphilis among blood donors in Africa. Targeted interventions in high-prevalence regions,
303 particularly Central and Western Africa, are essential to reduce the risk of transfusion-
304 transmitted infections. Strengthening blood donor screening protocols and implementing
305 contextually appropriate syphilis prevention programs are imperative.
306 The temporal trends we found in our study indicated a decline in syphilis seroprevalence over
307 time, as evidenced by the inverse correlation between the year of study publication and
308 seroprevalence. This trend suggests improvements in public health interventions, including

enhanced blood donor screening protocols and syphilis control programs. However, sustained efforts are required to achieve further reductions. Similar declines have been reported in other studies, reflecting the global efforts to reduce the burden of syphilis through integrated prevention and treatment strategies[18, 25]. The decline in seroprevalence over time is encouraging and indicates the positive impact of public health initiatives.

In the meta-regression analyses, we identified significant contributors to heterogeneity, such as the year of publication, risk of bias, and the country of study. Notably, the country where the study was conducted accounted for 26.84% of the heterogeneity, underscoring the influence of local factors such as healthcare policies, cultural norms, and epidemiological surveillance systems. The African region (9.41%) and study year (7.27%) also contributed to explaining heterogeneity, highlighting the dynamic and context-specific nature of syphilis epidemiology. The high risk of bias in some studies (8.11% contribution to heterogeneity) suggests the need for rigorous methodological design in future research to ensure accurate prevalence estimates. This need for rigorous methodological design, reporting and publication is particularly important given the asymmetry observed in the funnel plot and the significant result of Egger's test, indicating potential publication bias.

Longitudinal studies examining the interplay of social, environmental, and healthcare-related factors influencing syphilis prevalence are crucial for designing effective interventions.

Our study has limitations that need to be considered when interpreting our findings: 1) High heterogeneity: Despite efforts to account for variability, the high level of heterogeneity (I^2 = 100%) limits the generalizability of the pooled estimates and indicates substantial differences in study contexts and methodologies. 2) Publication bias: The presence of publication bias, as indicated by Egger's test and visual funnel plot asymmetry, suggests that studies with significant findings may have been preferentially published, potentially skewing the results. 3) Risk of bias in included studies: Some included studies had a high risk of bias, which may have

influenced the overall prevalence estimates and contributed to heterogeneity. Therefore, future research should prioritize robust, methodologically sound studies to reduce bias and enhance the reliability of prevalence estimates. 4) Limited data from certain regions: The number of studies included from some African regions, such as Northern and Southern Africa, was relatively small compared to Western, Eastern, and Central African regions, which may have impacted the precision of regional estimates and undermining the generalizability of our findings to whole Africa. 5) Cross-sectional nature of data: Most of the included studies were cross-sectional, limiting the ability to establish causal relationships or assess temporal changes within individual studies. 6) Potential variability in diagnostic methods: Differences in syphilis diagnostic techniques and screening protocols across studies may have influenced the prevalence estimates, introducing additional variability. Addressing these limitations in future research, such as through standardized methodologies, longitudinal designs, and increased representation from underreported regions, will be crucial for obtaining more accurate and generalizable estimates.

Despite the above limitations, our study has several strengths: 1) Comprehensive coverage: This study systematically assessed syphilis seroprevalence among blood donors across multiple African regions, providing a robust and continent-wide perspective on the epidemiology of syphilis. 2) Advanced analytical techniques: Meta-regression and subgroup analyses allowed for identifying key moderators of heterogeneity, such as region, publication year, and risk of bias, offering nuanced insights into factors influencing syphilis prevalence. 3) Temporal trends analysis: By exploring trends over time, the study highlighted the progress in reducing syphilis prevalence, which has critical implications for public health planning and evaluation.4) Public health relevance: The findings provide actionable data for policy-making, particularly for blood donor screening and syphilis control programs in high-prevalence regions.

Conclusion

The study found a pooled seroprevalence of syphilis among African blood donors at 2.47%, with significant regional variations, the highest in Central (4.57%) and the lowest in Southern Africa region (0.20%). Syphilis prevalence has declined over time, especially in studies published after 2010. Heterogeneity was largely influenced by study location, year of publication, and risk of bias, while publication bias was evident. These findings highlight the need for region-specific interventions, improved blood donor screening, and more standardized, recent research to guide public health policies effectively.

List of abbreviations

ELISA: Enzyme-linked immunosorbent Assay

FD: Family Donors

FTT: Freeman-Tukey double arcsine transformation

HBV: Hepatitis B Virus

HCV: Hepatitis C Virus

HIV: Human Immunodeficiency Virus

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analysis

QGIS: Quantum Geographic Information System

RDTs: Rapid diagnostic tests

RD: Replacement or Paid Donors

RT-PCR: Real-time polymerase chain reaction

RPR: Plasmin Reagin Test

STIs: Sexually Transmitted Infections

TPHA: *Treponema pallidum* Hemagglutination Assay

TTIs: Transfusion-transmitted infections

VDRL: Venereal Disease Research Laboratory

VNRBD: Voluntary Non-Remunerated Blood Donors

WHO: World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Availability of data and material

The data used during this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors declare that they have not received any funding for this work.

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AQ: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

NC: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

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AS: Conceptualization, Investigation, Supervision, Validation, Writing – review & editing.

LA: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing, Formal analysis, Writing – original draft.

All the authors read and approved the final manuscript.

Acknowledgments

The authors would like to acknowledge the Department of Community Medicine, Information and Decision in Health of the University of Porto and the Center for Health Technology and Services Research to conduct this systematic review and meta-analysis. We are grateful to the studies' authors included in this systematic review and Professor Milaydis Sosa Napolskij, who proofread the text.

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PUBLICAÇÃO 6

Incidence of Hepatitis B and C in Voluntary Blood Donors in a Private Clinic in Angola from 2011 to 2016.

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Advance Research Journal of Multidisciplinary Discoveries

I Vol. 48 Issue-1 Chapter-1. E-ISSN: 2456-1045, 2020


ARJMD
(Hard Copy)
E-ISSN : 2456-1045
International Journal
Most Cited Journal
Peer Review Journal
Indexed Journal
Open Access Journal
University Recognized Journal
RESEARCH JOURNAL
VOLUME - 48 | ISSUE - 1
ADVANCE RESEARCH
JOURNAL OF
MULTIDISCIPLINARY DISCOVERIES
APRIL
2020
INTERNATIONAL JOURNAL FOUNDATION
Specialized in academic publishings only
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ORIGINAL RESEARCH ARTICLE

ISSN : 2456-1045 (Online)
ICV Impact Value: 72.30
GIF- Impact Factor: 5.188
IPI Impact Factor: 3.54
Publishing Copyright @ International Journal Foundation
Article Code: MDS-V48-I1-C1-APR-2020
Category : MEDICAL SCIENCE
Volume : 48.0 (APRIL-2020 EDITION)
Issue: 1(One)
Chapter : 1 (One)
Page : 01-07
Journal URL: www.journalresearchijf.com
Paper Received: 20.03.2020
Paper Accepted: 25.05.2020
Date of Publication: 20-06-2020

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ABSTRACT

Objective: Screening blood donors for sexually transmitted diseases is becoming increasingly important. Donors are referred to screening centres, thus ensuring the quality of blood transfusions and avoiding transmission of the hepatitis B and C viruses. This study aimed to identify the incidence of positive serological markers for hepatitis B and C among blood donors. A retrospective descriptive prevalence study was carried out using the data base of serological positive markers for hepatitis B and C, the surface antigen of the hepatitis B virus (HBsAg), the positive hepatitis B core antibody (HBcAc), the antibody to the hepatitis C virus (anti-HCV). A total of 2734 donors were followed from 2011 to 2016 at Clínica Girassol, Angola. Analysis was carried out using the statistical data analysis program SPSS® v.22.0.

Results: Donors were aged between 18 and 64 years (median age of 32 ±9); 1373 (50.2%) donors tested positive for HBsAg, 731 (62.9%) for HBcAc and 140 (5.1%), were positive for anti-HCV. The majority, tested were men with 2467 (90%) and 267 (10%) were women. In conclusion, the study demonstrated the importance of screening to ensure donor blood safety and avoid transmission of infections by blood transfusion.

KEYWORDS: Donor Blood, Prevalence, Epidemiology.

CITATION OF THE ARTICLE

Quintas A.E., Cogle A.D.C., Dias C.C., Pereira A.C., Sarmento A.C., Cordeiro L.B. (2020) Incidence of hepatitis B and C in voluntary blood donors in a private clinic in Angola from 2011 to 2016; *Advance Research Journal of Multidisciplinary Discoveries;* 48(1) pp. 01-07

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I. INTRODUCTION

Screening blood donors for sexually transmitted diseases is becoming more and more important [1]. Hepatitis B and hepatitis C are diseases transmitted both through sexual contact and through blood. The risk is believed to be high in countries in sub-Saharan Africa [2], which is why the World Health Organization (WHO) has implemented norms for safe blood transfusion [3]. Accordingly, Angola complies with the rules for obligatory screening of blood donors [4].

Blood donors are referred to centres where this compulsory screening is carried out. The Immunohaemotherapy Service of the Clínica Girassol has been receiving an increasing number of donors for compulsory screening, in order for them to be able to donate blood. Initial assessment of these donors includes tests to identify markers for hepatitis B and hepatitis C, and if these are found to be positive, the patients are referred to a specialist. Other factors assessed in the potential donor are alcohol and medication consumption and other sexually transmitted diseases, namely Human Immunodeficiency Virus (HIV) and syphilis. Assessment of the donor's comorbidities is crucial in defining the risks that blood donation may present.

II. MATERIAL AND METHODS

This study is a retrospective descriptive prevalence study, analysing blood donations from donor records for the years 2011 to 2016 at Clínica Girassol, Luanda, Angola. Was approved by the Research Ethics Committee of the Institute of Public Health of the Republic of Angola number 25-2017 and 04-2018, all blood donors gave written individual consent and the Ethics Committee also allowed disclosure of the data.

All donated blood is tracked. The methods were carried out in accordance with the guidelines, regulation and consent for the study.

There are several units with equipment for blood collection, screening and transfusion, including the Clínica Girassol, which also complies with the rules. However, the drawback is that in this type of blood donation many diseases are detected.

The Immunohaemotherapy Service follows the guidelines for compulsory screening of blood donors. The Enzyme-Linked Immunosorbent Assay (ELISA) test was used to screen for hepatitis B virus surface antigens (HBsAg), hepatitis B virus core antibodies (HBcAc) and hepatitis C virus antibodies (anti-HCV).

In order to assess the results, a retrospective study of the donor database was undertaken. Between 2011 and 2016, 2734 adult blood donors were observed between the ages of 18 and 64; the demographic data of the donors was recorded and HBsAg, HBcAc and anti-HCV status. These tests are mandatory for all blood donors: they were not performed for the purpose of the study. Our aim was to discover, in this sample of blood donors, those who had positive results from diseases transmissible by blood transfusion. Donor screening is in place in Angola. There are health facilities that have equipment for blood collection and transfusion as well as screening. Blood and plasma of voluntary donors and their families was collected in the province of Luanda, according to the regulations and norms for blood collection. Using appropriate collection tubes, five millilitres (5ml) of blood was taken from each donor, which was kept at the recommended temperature.

Screening for HBsAg and HBcAc

Screening for HBsAg was undertaken using kits for the ELISA ARCHITECT test, as well as Abbott *i*1000Sr (ARCHITECT HBsAg and HBcAc qualitative screening kit). The test procedure and the interpretation of the results were undertaken according to the instructions in the manufacture's manual. Samples with dubious results (grey area) were repeated using the same kit and a different methodology, and results were confirmed using the Roche Cobas 601. Samples which were repeatedly positive were considered to be anti-HBc positive.

Screening for HCV

Screening for the HCV antibody was performed using the techniques described above, using the kits for the ELISA ARCHITECT plus *i*1000Sr Abbott (Architect anti-HCV assay Kit). The test procedure and the interpretation of the results were undertaken according to the instructions in the manufacture's manual. Samples with dubious results (grey area) were repeated using the same kit and a different methodology, and results were confirmed using ADVIACentar XP Immunoassay system.

The laboratory of the Immunohaemotherapy Service is certified by IQNet Certified Management Systems.

Statistical analysis

Categorical variables are described as absolute and relative frequencies, continuous variables are described through median and standard deviations or from the median and percentiles, according to the symmetry of their distribution. The prevalence of infections was estimated and also categorized for each variable of interest, then presented as relative frequency (%) with respective confidence intervals at 95%. The power of the study is 80%. In order to test hypotheses on the independence of categorical variables, the Chi-square test of independence or Fisher's exact test was applied, as appropriate.

In all the hypothesis testing a level of α = 5% was considered significant. The analysis was undertaken using the statistical analysis program Statistical Package for the Social Sciences v22.0 (SPSS® v22.0).

Availability of data and materials

The data sets used and/ or analyzed during the current study is available from the corresponding author on reasonable request.

III. RESULTS

A total of 2734 donors were screened, who were mostly men (90%) and of Angolan nationality (98%). The age of the donors ranged between 18 and 64 years (average = 32 ± 9); <25 years, 590 donors (21.6%); 25-29 years, 678 donors (24.8%); 30-34 years, 539 donors (19.7%); 35-39 years, 386 donors (14.1%) and ≥40 years 541 donors (19.8%). The majority, of those who were tested 2467 (90%), were men and 267 (10%) were women. As regards the year of blood collection, an increase in donations was seen in the year 2016 (2%). A rate of 50.2% positive results were seen for HBsAg, 62.9% for HBcAc and 5.1% for markers for hepatitis C infection. See **Table 1.**

Table 1. Total distribution of donors observed (n = 2734)

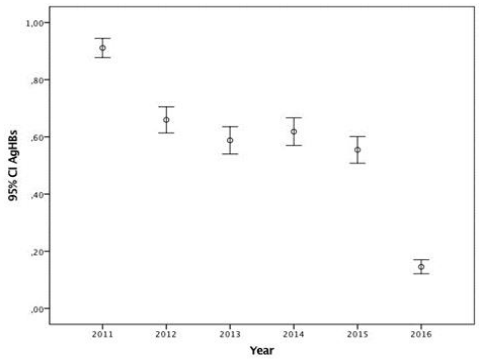
	n	(%)
Sex		
Male	2467	90%
Female	267	10%
Age, average (sd)	32 (9)	
<25	590	21.6%
25-29	678	24.8%
30-34	539	19.7%
35-39	386	14.1%
≥40	541	19.8%
Year of Collection		
2011	281	10.3%
2012	414	15.1%
2013	410	15.0%
2014	393	14.4%
2015	440	16.1%
2016	796	29.1%
Nationality		
Angolan	2671	97.7%
Non-Angolan	63	2.3%
HBsAg		
Positive	1373	50.2%
Negative	1361	49.8%
HBcAc*		
Positive	731	62.9%
Negative	432	37.1%
No information	1571*	-------
Anti-HCV		
Positive	140	5.1%
Negative	2588	94.9%
Dubious	3	-------
Not Tested	2	------
Indeterminate	1	------

**There is no information for these donors' HBcAc*

HBsAg

Statistically significant differences for gender, age and year of collection can be observed among donors with regard to positive results for HBsAg. There is a higher prevalence among male donors than female donors and this difference is statistically significant (51% [49-53] vs 40% [34-46], p < 0.01). As regards age, a decrease in positive results is observed as age increases, varying between 68% in donors under 25 years of age and 36% for donors over the age of 35 to 40, p < 0.001, see **Table 2**. A decrease in positive results is also observed regarding year of collection from 91% in 2011 to 15% in 2016 (p < 0.001), see **Figure 1**.

Figure 1. Frequency of HBsAg marker 2011-2016 (p < 0.001).



HBcAc

Statistically significant differences are observed for positive results for HBcAc for both age and year of collection. With regards to age, older donors present a lower prevalence (56% [50%-62%]), with donors between the ages of 25 and 29 presenting the highest prevalence (72% [66%-77%]). For year of collection, positive results also vary between 67% for 2014 and 83% for the year 2016, p < 0.001. Regular testing for the core antibody (HBcAc) began at the Clínica Girassol in 2016, which is why data are scarce for years 2011 to 2014.

Anti-HCV

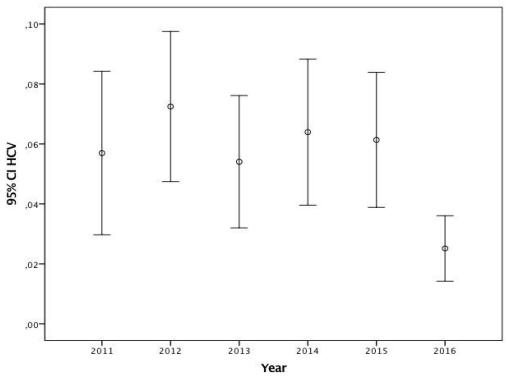
Statistically significant differences for gender, age of donor and year of collection can be observed in donors with regard to positive result for HCV. There is a higher prevalence among male donors than female donors (5% vs 2%, p < 0.001). With regard to age of donor, prevalence increases with age <25 years prevalence is 3% whereas it is 9% for donors over 40 years of age (p < 0.001), see **Table 2**. With regard to year of collection, a decrease is observed between 2011 and 2016 (6% vs 3%, p = 0.004), see **Figure 2**.

These results are alarmingly high since hepatitis B virus vaccination was available in these years, implying that we must intensify the vaccination campaign at the population level.

Table 2. Prevalence of TTIs (Transfusion-transmitted infections) in blood donors according to gender, age, year of collection and nationality.

	HBsAg positive			HBcAc positive			Anti-HCV positive		
	n total	n (%) [IC 95%]	p-value	n total	n (%) [IC 95%]	p-value	n total	n (%) [IC 95%]	p-value
Sex			**<0.001**			**0.663**			**0.011**
Male	2467	1266 (51) [49-53]		1045	659 (63) [60-66]		2461	135 (5) [5-6]	
Female	267	107 (40) [34-46]		118	72 (61) [52-70]		267	5 (2) [1-4]	
Age			**<0.001**			**0.004**			**<0.001**
<25	590	403 (68) [65-72]		236	141 (60) [53-66]		590	19 (3) [2-5]	
25-29	678	360 (53) [49-57]		280	201 (72) [66-77]		678	36 (5) [4-7]	
30-34	539	274 (51) [47-55]		244	152 (62) [56-68]		538	19 (4) [2-5]	
35-39	386	139 (36) [31-41]		178	111 (62) [55-69]		383	16 (4) [3-7]	
≥40	541	197 (36) [32-41]		225	126 (56) [50-62]		539	50 (9) [7-12]	
Year			**<0.001**			**<0.001**			**0.004**
2011	281	256 (91) [88-94]		0	0 (0) [-]		281	16 (6) [3-9]	
2012	414	273 (66) [61-71]		0	0 (0) [-]		414	30 (7) [5-10]	
2013	410	241 (59) [54-64]		0	0 (0) [-]		407	22 (5) [3-8]	
2014	393	243 (62) [57-67]		12	8 (67) [39-98]		391	25 (6) [4-9]	
2015	440	244 (56) [51-60]		357	71 (20) [16-24]		440	27 (6) [4-8]	
2016	796	116 (15) [12-17]		789	651 (83) [80-85]		795	20 (3) [2-4]	
Nationality			**0.501**			**0.056**			**0.255**
Angolan	2671	1344(50) [48-52]		1142	722(63) [60-66]		2665	135(5) [4-6]	
Other	63	29 (46) [34-58]		21	9 (39) [14-64]		63	5 (8) [3-16]	

Figure 2. Prevalence of anti-HCV 2011-2016 (p = 0.004).



IV. DISCUSSION

Screening for infectious disease (for the hepatitis B virus as well as hepatitis C) makes early diagnosis possible and subsequent referral of patients to specialized centres. Early diagnosis is crucial as it allows rapid therapeutic intervention, avoiding progression of the disease to cirrhosis of the liver and hepatocellular carcinoma [5].

This study reveals the seroprevalence of markers for the hepatitis B virus and hepatitis C in blood donors. A previous study of markers for the hepatitis B virus and hepatitis C undertaken in Luanda, revealed a prevalence of 40/431(9.3%) for HBsAg, while 35/431(8.1%) presented positive for anti-HCV [6]. Another study carried out at the Luanda public hospital revealed a prevalence of HBsAg of 77/508 (15.1%) and HBcAc 405/508 (79.7%), respectively [7].

In Africa, and particularly in Ethiopia, the prevalence of hepatitis B increases with age. In urban areas 75% of adults are infected and this is also true of many in rural areas [8]. A recent study carried out in the Democratic Republic of Congo showed a seroprevalence of 24.6% for hepatitis B and 2.3 % for hepatitis C [9]. On the other hand, a study carried out in the nearby countries of South Africa and Botswana showed that 72/950 (7%) of individuals were HBsAg positive [10].

In this study, the database for blood donors was used and a retrospective assessment was undertaken, for which 2734 donors were eligible. The results show that seroprevalence among apparently healthy blood donors was 1373/2734 (50%) for HBsAg, 731/1163 (63%) for HBcAc and 140/2734 (5%) for anti-HCV. Compared to other studies carried out in Angola and described above, an increase in seroprevalence for HBsAg is revealed with a decrease in anti-HCV. This significant increase in HBsAg findings could be explained by the increase in the number of apparently healthy volunteer donors who go to the clinic for obligatory screening. The study found that 69/314 (22%) tested positive for both HBsAg and HBcAc: this means that the donors were not aware that they were carriers of the hepatitis B virus and that when they completed the questionnaire at the blood bank they were considered asymptomatic blood donors, according to the WHO criteria.

The isolated presence of HBcAc found in 662/731 (91%) of donors, or reactivation of AcHBc does not necessarily indicate a high probability of transmission of infection, particularly in the absence of other markers for the hepatitis B virus. Screening for anti-HBc is considered an additional precaution for blood transfusion [11]. This position has led blood banks to adopt published algorithms for the implementation of screening for the anti-HBc marker [12], and would allow these blood banks to requalify anti-HBc positive donors for blood donation, thus reducing the loss of donors and at the same time, guaranteeing the safety of blood and other haemoderivatives [13],[14]. This is also why the Clínica Girassol, went on to administer the test routinely in 2016.

In the case of the hepatitis C virus, a rate of seroprevalence of 140 (5%) was found for blood donors who tested positive for the HCV antibody. As previously mentioned, the rate of seroprevalence in Angola among donors with positive anti-HCV was 8%. In this study, in a total of 2734 blood donors with positive markers for the infection, 140 presented a rate of seroprevalence of 5%. Seroprevalence of anti-HCV among donors was 135 (96%) in men and 5 (4%) in women.

This study shows that blood donors have high rates of seroprevalence both of HBsAg and HBcAc, but low rates of anti-HCV. This high seroprevalence is important because these donors were not aware that they were carriers of hepatitis B or hepatitis C and were considered asymptomatic. This study therefore reinforces the growing importance of obligatory screening of all blood donors.

In conclusion, these results show that we really are still a long way from halting the spread of hepatitis B; although vaccination is available we still have a high rate of infection and we need to intensify prophylactic measures.

V. LIMITATIONS

The study is mainly focused on donations for five years at Clínica Girassol. It would be crucial for the study to cover other institutions by analysing the characteristics of the donor for several years with a much larger population and for a longer period. The analysis of this study should be performed in several contexts for easy comparison with other studies. Further studies are likely to be conducted with the assistance of the Angolan Ministry of Health and may use the results of this study to assess the health and safety of blood donors in order to improve blood safety.

VI. AUTHOR'S CONTRIBUTIONS

Angelina Edna Quintas, were involved in the conception, design and written the study, **Adis Del Carmen Cogle**, was involved in interpretation of data. **Lemuel Cordeiro, Claúdia Camila Dias**, **Altamiro da Costa Pereira and António Sarmento** were involved in the conception and design of the study, interpretation of data, and drafting and revising the manuscript. All authors read and approved the final manuscript.

VII. ACKNOWLEDGEMENTS

The authors wish to thank all employees of the Immunohaemotherapy service that one way or another contributed to the collection of data for statistical analysis and Cláudia Camila Dias, Researcher in the Department of Community Medicine, Information and Decision in Health and the Centre for Research in Technology and Health Services, Faculty of Medicine, University of Porto, Portugal, for performing the statistical analysis of the data.

Competing interests

The authors declare that there is no conflict of interest.

Consent for publication

This study had the consent of the Research Ethics Committee of the Institute of Public Health of the Republic of Angola.

Ethical considerations

All blood donors gave written individual consent and the Ethics Committee also allowed disclosure of the data. With regard to confidentiality, no names were involved in processing the data as only codes were used to identify donors. This study had the consent of the Research Ethics Committee of the Institute of Public Health of the Republic of Angola number 25-2017 and 04-2018.

Funding

The authors declare that they have not received any funding.

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PUBLICAÇÃO 7

Trends in Human Immunodeficiency Virus Type 1/2 Prevalence Among Young Adult Blood Donors, from to 2011 to 2016, Attending A Private Clinic Private in Angola. Retrospective Study of Prevalence.

Quintas E, Cogle ADC, Caetano, Dias CC, Sebastião A, Dúnem-Van J, Pereira AC, Sarmento A, Cordeiro L

Journal of Infectious Diseases and Pathogenesis.

2018, Volume 1:206, Issue 2 ISSN: 2577-7939

Open Access

SCHOLARENA

Journal of Infectious Diseases and Pathogenesis

RESEARCH ARTICLE

ISSN: 2577-7939

Trends in Human Immunodeficiency Virus Type 1/2 Prevalence among Young Adult Blood Donors, from 2011 to 2016, Attending a Private Clinic in Angola. Retrospective Study of Prevalence

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Citation: Quintas E, Cogle ADC, Caetano F, Dias CC, Sebastião A, et al. (2018) Trends in Human Immunodeficiency Virus Type 1/2 Prevalence among Young Adult Blood Donors, from 2011 to 2016, Attending a Private Clinic in Angola. Retrospective Study of Prevalence. J Infect Dis Pathog 1: 206

Abstract

Introduction: The pandemic of the human immunodeficiency virus (HIV) continues to pose an enormous threat on a global scale. It is considered a public health problem worldwide, particularly in developing countries. It is therefore crucial to screen individuals at risk of infection which are common in Africa that is important to screen blood donations for this infection. This study aims to identify HIV positive 1/2 antibody in blood donors.

Objectives: It's about epidemiology study of prevalence, to identify HIV positive 1/2 antibody in blood donors.

Methodology: Epidemiology Study of Prevalence. A database of positive markers for HIV 1/2 antibody/antigen in blood donors was used, screened between 2011 and 2016.The analysis was carried out using the statistical data analysis program SPSS® v.22.0 (Statistical Package for the Social Sciences).

Results: The total prevalence of HIV was 191 (7%) donors out of 2734 presented positive results for the human immunodeficiency virus antibody. The majority (86%) 164 were men and 27 (14%) women. Ages ranged between 18 and 64 years, with an average of 32 ± 9 years

Conclusion: In this study, a seroprevalence rate of 7% for positive markers for the human immunodeficiency virus was observed, which means the impact on donors is high. This suggests that screening should be intensified.

Keywords: Donors Blood; Prevalence; Epidemiology

Introduction

Infection by the Human Immunodeficiency Virus (HIV) continues to represent a serious problem to public health on a worldwide scale, particularly in developing countries [1]. Angola, is situated in southwest Africa, and has a population estimated around 26,655,513 (data from 22-April, 2017) [2]. Luanda the capital and most populous city with 6,542,944 inhabitants [3]. To the north and northeast, Angola borders on the Democratic Republic of Congo and the Republic of Congo and to the east on Zambia, which all have high rates of infection by the HIV virus [4,5]. To the south it borders on Namibia, which has a seroprevalence rate of

9.1%, Botswana, with a rate of 22.9% and on Swaziland with a rate of 26.1% in women and with 2.8%, 8.3%, and 9.3% of men were HIV positive [6]. To the west it is bathed by the Atlantic Ocean. In these African countries, the infection is predominantly spread through sexual contact. In 2009, Angola presented a decrease in the prevalence of HIV/AIDS among the adult population 3.7% [7]. Currently it is more and more important to screen donors for diseases spread through blood transfusion [8]. A recent study undertaken in Angola, among men who have sexual relations with men, (MSM), a population size of 6236 was estimated, and 27 of 351 individuals tested were positwwive. The adjusted prevalence of HIV was 3.7% (8.7% crude) [9]. It is therefore crucial to screen individuals at risk of infection which are common in África that is important to screen blood donations for this infection. This study its about epidemiology study of prevalence, to identify HIV positive 1/2 antibody in blood donors, in Angola -Clínica Girassol.

The Immunohemotherapy Service receives donors who take part in obligatory screening as the initial assessment for potential blood donors.

Methodology

It is an Epidemiology Study of Prevalence. A database of positive markers for HIV 1/2 antibody and antigen in donors, screened between 2011 and 2016 was used. Demographic data was recorded and the analysis was carried out using the statistical data analysis program SPSS® v.22.0 (Statistical Package for the Social Sciences). The guidelines for obligatory screening of blood donors are strictly followed in this Service. The serological Enzyme-Linked Immunosorbent Assay (ELISA) test was used to screen for the antigen and antibody for Human Immunodeficiency Virus (anti-HIV).

This screening included 2734 adult blood donors with ages ranging between 18 and 64 years, of which 191 (7%) presented positive for the HIV antibody. Blood and plasma was collected from voluntary donors and their families in the city of Luanda according to the regulations and norms for collecting blood. The blood sample was taken from each donor using appropriate collection tubes and was conserved at the ideal temperature.

Screening for HIV 1/2 antibody and antigen

Screening for HIV 1/2 antibody and antigen was carried out using the Enzyme-Linked Immunosorbent Assay (ELISA) test plus i1000Sr Abbott (HIV-1/2 AgAc), sandwich ELISA for the detection of the HIV antigen and antibody, combo ELISA kit. The test procedure and the interpretation of the results were undertaken according to the instructions in the manufacture's manual. Samples with dubious results (gray area) were repeated using the same kit and a different methodology, and results were confirmed by ADVIACentaur XP Immunoassay System (Siemens).

Note: This screening test has a sensitivity and specificity of over 99%, according to the maker, with regular quality control. The laboratory of the Immunohemotherapy Service is certified by IQNet Certified Management Systems.

Statistical Method and Analysis

The categorical variables are described as absolute and relative frequencies, the continuous variables are described through median or standard deviations or from the median and percentiles, according to the symmetry of their distribution. The prevalence of infections was estimated and for each variable of interest, and presented as relative frequency (%) with the respective confidence interval at 95%. In order to test hypotheses on the independence of categorical variables, the Chi-square test of independence or Fisher's exact test was applied, as appropriate.

In all the hypothesis testing a significance level of α=5% was considered. The analysis was undertaken using the statistical analysis program SPSS® v22.0 (Statistical Package for the Social Sciences).

Ethical Approval and Consent to Participate

This study had the consent and was approved by the Research Ethics Committee of the Institute of Public Health of the Republic of Angola. Patients were only included after signature of the consent term. Consultations of patient's record were authorized by Clinical and General Directory of the Hospital. To confidentiality no names were involved in the data analysis process as only codes were used to identify donors. The authors claim there is no conflict of interest. With regard to confidentiality no names were involved in the data analysis process as only codes were used to identify donors.

Results

The total prevalence of HIV was 191 (7%) donors out of 2734 donors, presented positive results for the HIV1/2 antigen and antibody from January 2011 to June 2016. The profile of these donors was characterized by the predominance of the masculine sex, with 2467(90%).They were all adults aged between 18 to 64 years, with a median age of 32+9 and 98% of the donors had Angolan nationality. The prevalence of HIV between 2011 and 2016 was 7 [6-8%]. There were differences between prevalence and age, years and regions of Angola (Table 1).

	Total		HIV positive		
	n	(%)		% [CI 95%]	p-value
Sex					
Male	2467	90.2	164	6.6 [5.7-7.7]	0.081
Female	267	9.8	27	10.1 [7.0-14.3]	
Age					
<25	590	21.6	31	5.3 [3.7-7.4]	**0.019**
25-29	678	24.8	56	8.3 [6.4-10.6]	
30-34	539	19.7	32	5.9 [4.2-8.3]	
35-39	386	14.1	39	10.1 [7.5-13.5]	
>40	541	19.8	33	6.1 [4.4-8.4]	
Year					
2011	281	10.3	17	6.0 [3.8-9.5]	<0.001
2012	414	15.1	24	5.8 [3.9-8.5]	
2013	410	15.0	46	11.2 [8.5-14.6]	
2014	393	14.4	39	9.9 [7.3-13.3]	
2015	440	16.1	43	9.8 [7.3-12.9]	
2016	796	29.1	22	2.8 [1.8-4.1]	
Nationality					
Non Angolan	63	2.3	7	11.1 [5.5-21.2]	0.205
Angolan	2671	97.7	184	6.9 [5.9-7.9]	
Luanda	*1419*	*53.1*	*73*	*5.1 [4.1-6.4]*	<0.001
Others Regions	*1252*	*46.9*	*111*	*8.9 [7.4-10.6]*	
HIV					
Negative	2543	93.0	-	-	-
Positive	191	7.0 [6.1-8.0]	-	-	-

Table 1: Prevalence of Infection by HIV among blood donors. Luanda, 2011-2016

The greatest prevalence of infection by HIV among donors was associated with the 35-39 years old age group, with 39 cases (10.1%), and the lower was observed in patients with less than 25 years old age with 31 cases (5.3%) - Figure 1.

When the test was carried out in Luanda, seroprevalence was observed in 73 donors who presented positive for the HIV antigen and antibody, which corresponds to 5.1% of those screened. Other provinces (Bíe, Bengo, Benguela, Cabinda, Cunene, Huambo, Huíla, Kuando Kubango, Lunda-Norte, Lunda-Sul, Kwanza-Norte, Kwanza-Sul, Malange, Moxico, Namibe, Uíge), presented 111 (8.9%) positive cases – Table 1. The prevalence of HIV among years decrease from 6.0% [3.8-9.5 in 2011 to 2.8% [1.8-4.1] in 2016 Figure 2.

This decrease in prevalence of HIV markers in donors of 2011 to 2016, due to the fact that the Clínica Girassol, makes exclusively service in private patients, which somehow restricts access to most of the population.

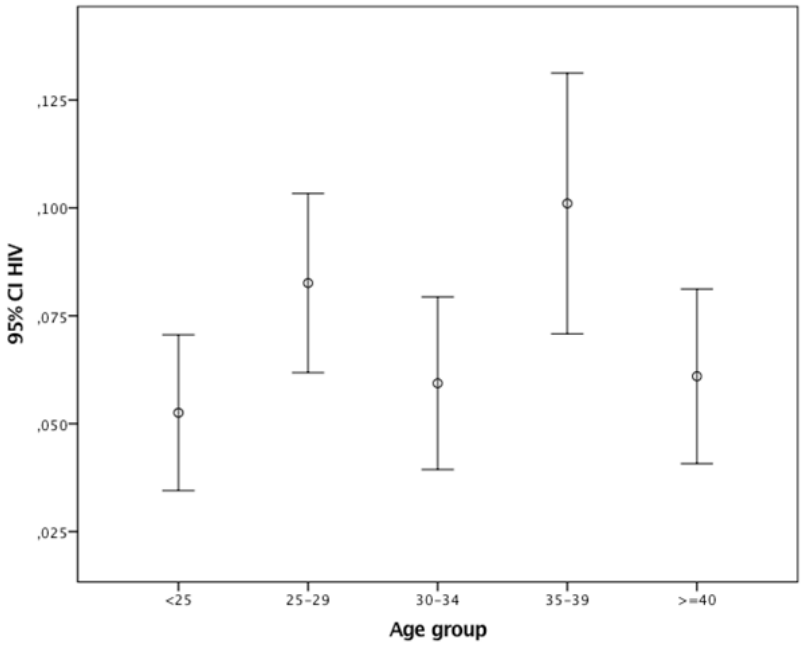

Figure 1: Prevalence of HIV across age

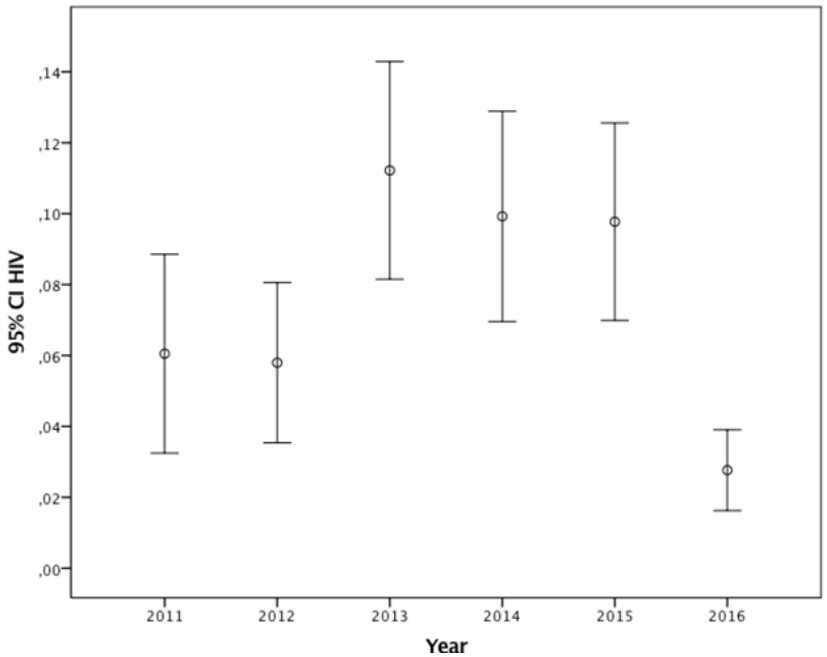

Figure 2: Prevalence of HIV among years

This decrease in prevalence of HIV markers in donors of 2011 to 2016, due to the fact that the Clínica Girassol, makes exclusively service in private patients, which somehow restricts access to most of the population.

Discussion

The results of this present study show a high prevalence of HIV (7%), and the highest rates are associated to the younger age

groups. A study carried out in a Brazil in prison in Florianopolis (Brazil) showed that among a sample of 147 individuals the prevalence of HIV was (2.1%) [10]. Another study undertaken in the same space among 1200 men who have sex with men (MSM), 25 participants presented positive for the ELISA test, with the result observed on different occasions and confirmed by a positive Western Blot test. The prevalence in this group was 12.7% and in Cambodia a study among transsexuals showed a 4.15% prevalence [11-13]. A further study carried out among blood donors in Ethiopia revealed seroprevalence of HIV of 3.16%. In Nigeria, the study carried out between 2008 and 2013 among 3081 patients testing positive for HIV showed that the prevalence increased in 2008 (32.8%) and 2009 (26.6%), with a reduction of the rate in 2010 (5.7%), 2011 (16.6%) and 2012 (8.3%), respectively [15]. The results of this present study show a high prevalence of HIV (7%), when compared with other countries, for example Ethiopia, Nigeria in 2010, and the highest rates are associated to the younger age groups. It should be remembered that Angola is host to people of various nationalities, that they also undergo screening of they attend the clinic. Among these individual 7(4%) presented positive for the HIV antigen and antibody.

Strengths and Limitations

An important finding of this study was that the prevalence of 7% observed in blood donors who used the Clínica Girassol during this time period may be low considering other results. However, it is noteworthy that the individuals who seek in the Clínica, mostly have better resources and information about HIV, which does not occur in public hospitals in the countries in the studies above, which we consider a limitation of the study and be accomplished only in a private clinic, where not all individuals are able to resort to Financial Institution for screening.

Conclusion, Recommendation and Future Directions

In this study, reinforcing the need for screening. Accordingly, educational campaigns must be intensified, fostering the adoption of safe practices. They will be all the more effective if they are integrated in health promotion campaigns for this population, blood donors. A seroprevalence rate of (7%) was observed for positive markers for the human immunodeficiency virus, which means that the impact of the epidemic on donors is high. A cohort study, nested in this study could show us the impact of this disease on donors.

Competing Interests and Funding

The authors declare that they have no competing interests and they have not received any funding.

Authors contributions

All the authors participated, read and approved the final manuscript.

Cordeiro BL and Dias CC and Altamiro CP and António Sarmento was involved in the conception and design of the study, interpretation of data, and drafting and revising the manuscript; Cogle PCA was involved in the collection of data for statistical analysis; Caetano Fátima and Sebastião Adriana, all authors and Van-Dúnem J, reading, confirming and approved the final manuscript.

Acknowledgement

The authors wish to thank all employees of the Immunohemoterapy Service the Clínica Girassol, that one way or another contributed to the collection of data for statistical analysis.

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PUBLICAÇÃO 8

Prevalence of Syphilis in Blood Donors in Angola from 2011 to 2016.

Edna Quintas, Adis Del Carmen Cogle, Adriana Sebastião, Altamiro da Costa Pereira, António Sarmento, Joaquim Van-Dúnem and Lemuel Cordeiro

Clinical And Medical Reports

2018. Volume 2(1):1-4 ISSN:2516-5283

Clinical and Medical Reports

Research Article ISSN: 2516-5283

Prevalence of syphilis in blood donors in angola from 2011 to 2016

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Abstract

Introduction: transfusion-associated infections mainly caused by bacteria or virus among blood donors are of concern to public health. Blood transfusion practices around the world emphasize safety and the protection of human life.

Objectives: the aim of this study, is to identify positive serology for syphilis in blood donors.

Methodology: A retrospective descriptive study of prevalence was made. We analyzed the database of records of blood donors, screened from 2011 to 2016, with positive syphilis serologies. The demographic data was recorded and analyzed using SPSS software, version 22.0.

Results: out of a total of 2734 donors, 436 (20%) had positive syphilis serology. The majority (88%) 384 were men and 52 (12%) women. Ages ranged between 18 and 64 years, with an average of 31.95 ± 8.9.

Conclusion: in this study, a seroprevalence rate of 20% was observed for positive syphilis serology, which means the impact of the disease on donors is high, this suggests that screening should be reinforced.

Introduction

It is well-known that since historic times, due to the significant increase in the number of cases diagnosed, syphilis has been an exceedingly important challenge for public health [1-3]. The World Health Organization (WHO) estimates that approximately one million people are infected daily worldwide by one or more sexually transmitted diseases (STD) and for 2010 they estimated 11 million new cases of syphilis. For 2012 they estimated a 10% increase in the regional and global prevalence in new cases of syphilis for men and women. This situation merits careful consideration as it contributed to an increase in high risk populations [3-6]. Syphilis is a bacterial infection caused by *Treponema pallidum*, which is endemic in low income countries and which occurs at lower rates in middle and high-income countries [7]. Apart from its direct morbidity it increases the risk of infection by the Human Immunodeficiency Virus (HIV) and may cause lifelong disease in children born to mothers infected. It is a disease which, if not treated, will progress over the years through a series of clinical states, and may lead to irreversible cardiovascular and neurological complications. A study undertaken in the USA among men who have sex with men, which was published in July 2017, revealed that the diagnosis of cases of syphilis increased from 9% in 2008 to 11% in 2014, mainly among men aged between 25 and 29 (6% -10%) and among black Africans (9%-14%) [8]. In another study carried out in Brazil, the prevalence of syphilis was 6,3% greater among males (7,5%) than among females (4,3%, $p < 0,001$). Syphilis was associated with the age group 25-34 years, with people with a low level of education and the unmarried persons [9].

In neighboring Mozambique (8%), South Africa showed a decrease in the seroprevalence rate for syphilis among fertile women between 12 and 49 years of age. In 2003 the rate was 8,6% and in 2011 it was 3,8% [10,11]. In a survey carried out in Sierra Leone, the estimated prevalence ranged between 1,5% and 5,2% based on regional studies [12].

Data from the Angolan Health Ministry estimated new cases of STD in Angola, showing 19%, 18,5% and 13,9% of prevalence of syphilis in the provinces of Luanda, Huíla and Benguela respectively among pregnant women at a pre-natal appointment. However, sex workers in the province of Luanda showed a prevalence of 34,1% (Available at www.ilo.org/public/scielo. Accessed on 27/07/2017 at 12h and 47min).

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Key words: *Blood Donors, Prevalence, Syphilis, Epidemiology*

Received: April 17, 2018; **Accepted:** May 09, 2018; **Published:** May 14, 2018

A 2013 study in Angola/Luanda showed a seropositivity rate for syphilis of 4.6% [13].

A study published in 2015 covering 43 countries in sub-Saharan Africa revealed that countries such as the Democratic Republic of Congo, Nigeria, Ethiopia and Tanzania presented an increased rate for syphilis as did Swaziland, and Uganda [14-16].

The aim of this study was to analyze seropositivity for syphilis in blood donors.

Methods

This study is a retrospective descriptive prevalence study, analyzing blood donations from donor records for the year 2011 to 2016 at Clínica Girassol, Luanda, Angola.

In order to assess the results, a retrospective study of the donor database was undertaken. The demographic data of the donors was registered, between 2011 and 2016 and 2734 adult blood donors were observed between the ages of 18 and 64. The analysis was carried out using the statistical data analysis program SPSS ® v.22.0 (Statistical Package for the Social Sciences).

Blood and plasma of voluntary donors and their families was collected in the province of Luanda, according to the regulations and norms for the collection of blood. Using appropriate collection tubes, five milliliters (5ml) of blood was taken from each donor, which was kept at the ideal temperature.

The laboratory of the Immunohemotherapy Service is certified by IQNet Certified Management Systems.

*Serology for Syphilis

Screening for the antibody (IgG e IgM) for *Treponema pallidum* (TP) is undertaken using Kits for Enzyme-linked immunosorbent assay test (ELISA) ARCHITECT plus *i*1000Sr Abbott. All reactive results were tested twice. If both tests were non-reactive, the initial result was considered negative. Syphilis was tested using the automated method for *Treponema pallidum* Hemagglutination Assay (TPHA) which, if it was reactive twice, was repeated as confirmation using the manual method for the procedure TPHA and VDRL (Veneral Disease Research Laboratory). The latter is considered more specific, giving the final result. Was considered syphilis when the results of TPHA and VDRL were positive.

Statistical analysis

The categorical variables are described as absolute and relative frequencies, the continuous variables are described through median or standard deviations or from the median and percentiles, according to the symmetry of their distribution. The prevalence of infections was estimated and for each variable of interest and presented as relative frequency (%) with the respective confidence interval at 95%. In order to test hypotheses on the independence of categorical variables, the Chi-square test of independence or Fisher's exact test was applied, as appropriate.

In all the hypothesis testing a significance level of $\alpha = 5\%$ was considered. The analysis was undertaken using the statistical analysis program SPSS® v22.0 (Statistical Package for the Social Sciences).

Ethical considerations

This study had the consent of the Research Ethics Committee of the Institute of Public Health of the Republic of Angola. With regard to confidentiality no names were involved in the data analysis process as only codes were used to identify donors.

Results

From 2734 donors include in the study, 546 had not a record of syphilis in the database and 4 were dubious. A total of 2184 donors were analyzed. The profile of these donors was characterized by the predominance of the masculine sex, with 1969 (90%). They were all adults aged between 18 to 64 years, with a median age of 32 ± 9 and 98% of the donors had Angolan nationality.

The prevalence of syphilis between 2011 and 2016 was 20.0% [18.3-21.7%]. There were differences between prevalence and age and nationality – (Table 1).

Concerning age, patients with more than 40 years had a higher prevalence than the others 37.4 [33.1 – 42.0] $p < 0.001$ – (Figure 1). Between 2011 and 2016 the highest prevalence observed was 41.1% [35.4-47.1] in 2012 and the lowest in 2016 with 5.6% [4.1-7.5%]- (Figure 2).

Discussion

Togo, officially known as The Republic of Togo, an African country bordered to the north by Burkina Faso, to the east by Benin, to the south by the Atlantic Ocean and to the west by Ghana, presents a rate of 2,2% of syphilis among female sex workers, compared to 2,3% for other clients [5]. Countries which border on Angola present a high rate of seroprevalence for syphilis. A study undertaken in 2011 and published in 2014 among women attending pre-natal clinics showed that the Democratic Republic of Congo presented a rate of seroprevalence of 4,2% and among demobilized soldiers it was 3, 4%, with an equal distribution in relation to sex and location [17,18]. The prevalence of syphilis observed in Zambia was 9,3% 0,4% in Botswana [14,19].

Table 1. Prevalence of infection by *Treponema pallidum* among blood donors. Luanda, 2011-2016.

	Total		Syphilis positive		
	n	(%)		z% [CI 95%]	p-value
Género					0.103
Male	1969	90.0	384	19.5 [17.8-21.3]	
Female	215	10.0	52	24.2 [18.9-30.3]	
Age					
<25	444	20.3	40	9.0 [6.7-12.0]	
25-29	540	24.7	64	11.2 [9.4-14.9]	
30-34	440	20.1	80	18.2 [14.9-22.1]	**<0.001**
35-39	314	14.4	85	27.1 [22.5-32.2]	
≥40	446	20.4	167	37.4 [33.1-42.0]	
Year					**<0.001**
2011	80	3.7	5	6.3 [2.7-13.8]	
2012	265	12.1	109	41.1 [35.4-47.1]	
2013	321	14.7	110	34.3 [29.3-39.6]	
2014	351	16.1	88	25.1 [20.8-29.9]	
2015	430	19.7	83	19.3 [15.8-23.3]	
2016	737	33.7	41	5.6 [4.1-7.5]	
Nationality					0.828
Non-Angolan	52	2.3	11	21.2 [12.2-34.0]	
Angolan	2132	97.7	425	19.9 [18.3-21.7]	
Luanda	1131	53.1	171	15.1 [13.2-17.3]	
Other Regions	1001	46.9	254	25.4 [22.8-28.2]	**< 0.001**
Shyphilis					
Negative	1748	80	-	-	-
Positive	436	20.0 [18.3-21.7]	-	-	-

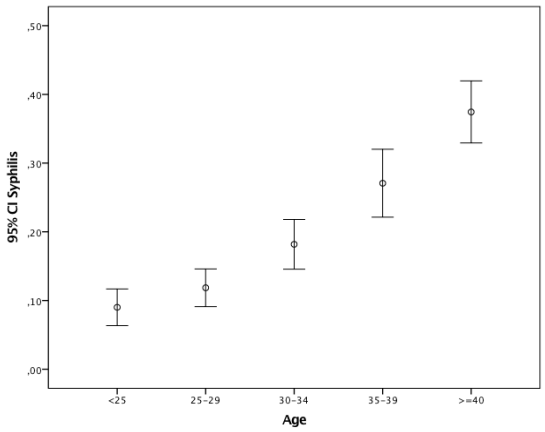

Figure 1. Prevalence of infection by *Treponema pallidum* among blood donors Age. Luanda, 2011-2016

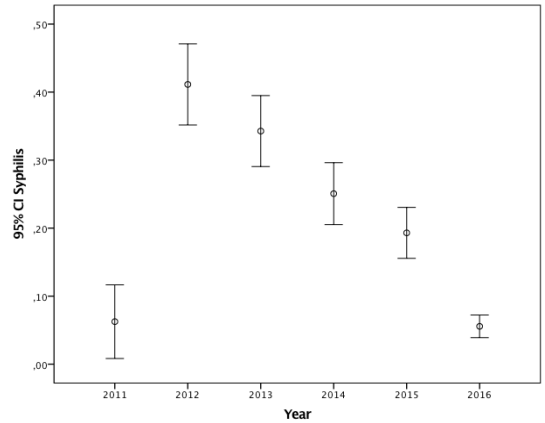

Figure 2. Prevalence of infection by *Treponema pallidum* among years blood donors. Luanda, 2011-2016

In a study published in 2014, in comparison with other findings for other countries mentioned above, Namibia presented a low rate of seropositivity for syphilis, with 0,3% of donations positive for the infection [20]. Other study in Ghana who compare laboratory practices for screening blood donors for syphilis estimated that syphilis seroprevalence in voluntary donations was 2.9%, compared to 4.0% in family donations (p = 0.001), when compared to these countries, Angola still maintains high levels of seropositivity for syphilis [2,21].

This present study showed that 20% of donations were positive for syphilis, a high rate when compared to neighboring African countries. This decrease in prevalence of Syphilis markers in donors of 2011 to 2016, due to the fact that the Clínica Girassol, makes exclusively service in private patients, which somehow restricts access to most of the population.

Conclusion

In this study it was observed that the prevalence of syphilis continues high in Angola (20%), and that these results do not differ greatly from the estimates suggested by the Angolan Health Ministry from 2003-2008. It is urgent to increase awareness campaigns and to encourage the use of condoms among this key population group and underprivileged classes, to intensify campaigns for the prevention and control of syphilis particularly among populations considered the most vulnerable.

Limitations

Be accomplished only in a private clinic, where not all individuals are able to resort to Financial Institution for screening.

Competing interests

The authors declare that they have no competing interests.

Authors contributions

All the authors participated, read and approved the final manuscript.

Acknowledgements

The authors wish to thank all employees of the Immunohemoterapy Service the Clínica Girassol, that one way or another contributed to the collection of data for statistical analysis.

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