Experiences and lessons from the resilience and sustainability of public health supply chain during the war in Sudan

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Abstract

Background: A resilient public health supply chain will ensure the sustainability and accessibility of essential medicines during a conflict as demonstrated during the war in Sudan.

Aim: To assess the resilience and strategies adopted to sustain and strengthen public health supply chain during the war in Sudan.

Methods: We conducted a comprehensive review and analysis of electronic databases for information on public health supply chain systems during the war in Sudan between the period April 2023 to December 2024; particularly information relating to governance and leadership, procurement and financial resources, warehousing and storage, distribution and logistics, supply chain workforce, and information systems.

Results: The National Medical Supplies Fund adopted some strategies to enhance public health supply chain during the war, including diversification and decentralisation. These measures improved medicine availability, strengthened storage and distribution systems and facilitated the recovery 70% of the cold chain capacity. Essential health products were delivered to 17 of 18 states, although the quantity and frequency of deliveries varied according to the security and access conditions. The supplies covered 90% of the functional health facilities.

Conclusion: Despite the complex war challenges, Sudan's health supply chain achieved remarkable resilience, strengthening performance and delivery of essential health products, and reducing the negative effects of the war.

Keywords: resilience, health system, supply chain, essential medicine, war, conflict, Sudan

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Introduction

Ensuring access to safe, efficacious, quality medicines is central to the achievement of the United Nations Sustainable Development Goal 3: "ensure healthy lives and promote well-being for all" (*1*). This goal is critical to strengthening health systems and supporting Universal Health Coverage; a strategic priority for WHO and many countries (*2–4*).

Sudan's large size and challenging environment require substantial investment in the health supply chain to ensure availability of essential medical interventions (*5*). In Sudan, the National Medical Supplies Fund (NMSF) is a semi-autonomous government entity responsible for the procurement, storage and distribution of medicines and other medical products, based on the concept of cost recovery (*5*). NMSF has implemented reforms through several initiatives and interventions across public health supply chain functions to improve geographic, physical and economic accessibility of quality essential medicines and other health products (*6*). These initiatives include, for example, adoption of a new procurement policy with cross-subsidisation, long-term contracts and pooled electronic procurement (the first of its kind in Africa). NMSF introduced an online supply service and outsourced transportation of medical products to boost the efficiency of the distribution system (*6*).

NMSF established branches in 17 states and invested approximately US$ 48 million to strengthen these branches and improve the national health supply chain. This investment included the construction of warehouses, provision of supervision cars and temperature-controlled vehicles, implementation of comprehensive human resource development programmes, refurbishment of pharmacies, and installation of computers and software. Since 2010, an enterprise resource planning system and an electronic logistics management information system have been operated at central and state levels to enhance efficiency and transparency across supply chain operations (*6*). These comprehensive reforms and investment in the supply chain have had a significant impact on the performance of Sudan's national supply system for essential medicines (*7*).

The current war erupted on 15 April 2023 in Khartoum and spread across most states, causing political instability and serious health, social and economic consequences for the entire population (*8,9*). The war has resulted in a shortage of medicines due to looting of strategic stocks and fleets; extensive damage to NMSF warehouses in 8

states; and difficulties in delivering medicines caused by insecurity, destruction of infrastructure, increasing service costs, and fuel shortages. For example, NMSF lost more than 130 vehicles, including supervision vehicles and temperature-controlled trucks, in Khartoum and other war-affected states. The war has caused shortages of health workers at all levels. NMSF lost its data centre in Khartoum State, resulting in the loss of its enterprise resource planning system and the electronic logistics management information system (*10*,*11*). The overall financial losses in the health supply chain due to the war have been estimated to be more than US$ 500 million (*10*,*11*).

The war highlights the importance of establishing a resilient public health supply chain to ensure the sustainability and accessibility of life-saving and essential medicines across the country. To address the supply chain challenges during the war, NMSF and the Federal Ministry of Health (FMOH) implemented strategies to ensure sustainable procurement and distribution of essential medicines and continuity of health supply services throughout Sudan (*10*,*11*). This study assessed the resilience of the public health supply chain and the early preparedness, capacity, management, and strategies that were adopted by NMSF and FMOH to sustain and strengthen the health care supply chain during the war.

Methods

We conducted a comprehensive desk review of multiple data sources containing information and insight on Sudan's public health supply chain system during the war. The review involved searches in the following electronic databases: digital library searches, such as WHO IRIS; grey literature, including relevant FMOH and NMSF documents, such as policies, emergency response reports, evaluation reports, statistical records, and health and national supply chain strategies; and situation reports of United Nations agencies in Sudan. The study covered the period from the onset of the war in April 2023 to December 2024. Specifically, databases such as PubMed and Google Scholar were searched using the following keywords: health supply chain or medical supply chain or pharmaceutical supply chain, health system, resilience, sustainability, emergency, crisis or conflict or war, strategies, response, assessment framework, Sudan, alongside the logical operators AND/OR to refine the search. The searches covered the period 2010–2024.

We assessed 6 thematic areas of the supply chain system: governance and leadership, procurement and financial resources, warehousing and storage, distribution and logistics, supply chain workforce, and information systems. We applied the logical frameworks (input–process–output–outcome) as the assessment and evaluation tools. WHO considers this framework as added value because it brings together indicators and data sources across the entire supply chain. It is designed to assess the management of health system investment and performance, which is essential for national decision-making (*12*). Qualitative and quantitative indicators were used to monitor activities and measure the output and short to intermediate outcome (Table 1). These indicators were evaluated against the benchmarks or standards to assess whether the measures implemented by FMOH and NMSF improved health supply chain performance and sustainability during the war.

Before starting the data collection, ethics clearance was obtained from the NMSF Research Ethics Committee.

Results and discussion

The input–process–output–outcome framework assessed the inputs (human and financial resources, health commodities, infrastructure and technology); processes (emergency management, measures and strategies implemented by NMSF to sustain the public health supply chain during the war); outputs; and short to intermedi-

Table 1 Indicators used to assess health supply chain resilience

Thematic area	Indicators
Governance and leadership	Up-to-date national health supply strategy linked to national needs and priorities (*12*)
	Designated entity or structure with responsibility for the recovery following a public health event (*13*)
	National supply chain strategies that define the role of health supply services during emergency preparedness, response and recovery (*13*)
	Stakeholders are involved in national health planning and review (*14*)
Supply chain workforce	Ability of the health workforce to operate in multiple positions in a team or facility, especially when emergencies lead to absence of existing workers (*14*,*15*).
	Number of staff responsible for procurement and supply management who have been trained appropriately (*13*,*16*,*17*)
Procurement and financing	Availability of essential medicines; calculated as the number of NMSF key items with at least 1-month stock divided by the total number of key items (*16*,*17*)
Storage	Infrastructure upgrade (central and/or peripheral level), including physical warehouse infrastructure upgrade/increase of storage capacity (*18*)
Distribution	Percentage of health facilities that deliver prioritised health supply services (minimum 80%) (*16*)
Information system	Percentage of districts and hubs that submit timely, complete, accurate reports (inventory control, financial and received reports) at the national level (*12*,*13*)

Table 2 Thematic analysis structured by an input–process–output–outcome framework

Thematic	Inputs and processes/strategies	Outputs and short-intermediate outcomes
Governance and leadership	• Established and activated advisory and technical committees • Coordinated with partners and donors • Identified and prioritised a list of essential medicines to be secured through purchase or provided by donor • Developed a 5-years Sudan national humanitarian response, reform and recovery supply chain strategy. • Transferred the supply management to NMSF's branch in Al-Jazeera State, Kassala State and subsequently to Red Sea State after the rebel Rapid Support Forces occupied NMSF premises and warehouses in Khartoum	• During the first 2 weeks of the war, NMSF distributed > 200 lifesaving medicines to 21 hospitals in Khartoum and other states • During the first 6 months of the war, a national health supply chain strategy was developed, with the active participation of various stakeholders (governmental entities, donors, NGOs, etc.) • Implemented early response and measures • Maintained uninterrupted operations of the supply chain
Procurement and financial resources	• Sourced health products from multiple suppliers • Applied diverse procurement mechanisms • Introduced a swap mechanism with UNDP, through which NMSF deposited local currency into UNDP account, and UNDP allocated the equivalent amount in US dollars for purchasing medicines for NMSF (*19*) • Secured funding through grants and donation from other countries and UN organizations • Collaborated with the Ministry of Finance and National Economy to allocate emergency funds • Partnered with National Health Insurance Fund • Reallocated resources between supply chain budget lines • Task shifting for NMSF staff	• Improvement in the availability of medicines as a result of the emergency interventions and measures taken by NMSF • Emergency and lifesaving medicines availability increased from 45% in 2023 to 82% in 2024 • Oncology medicines availability increased from 37% to 81% • Renal dialysis and transplantation supplies increased from 30% in 2023 to 90% in 2024 • Blood bank and haemophilia medications availability increased from 52% to 75% • Cardiac catheters for diagnostic and treatment availability increased from 27% to 75%
Warehousing and storage	• Implemented storage decentralisation policies • Established regional hubs • Transferred and redistributed stocks across NMSF states' warehouses and hubs, depending on changes in demand, displacement and security conditions	• NMSF established 4 additional stores as regional hubs • Restored 11% of the storage capacity lost at the central level during the early months of the war • Early recovery of 70% of the lost cold chain through government support and donors
Distribution and logistics	• Adopted multiple distribution mechanisms, including NMSF's fleet, outsourcing delivery service, private trucks, and vehicles provided by UN agencies • Adopted NMSF distribution model • Used adaptive alternative transportation modes, such as airdrops and riverine routes, to reach inaccessible states • Cooperated with WHO, UNICEF, NGOs, local authorities, civil society organizations and community groups	• NMSF succeeded in delivering essential medicines and other health products at different quantities and frequencies to 17 of 18 states, although the size and frequency of deliveries varied according to security and access conditions • NMSF received, and distributed >27600 tons of medicines and medical consumables, valued at US$ 123 million, through government, grants and donations • Health products supplied through government and donation represented 64% and 36% of the total value of received and distributed health products, respectively • In states reached, NMSF succeeded in covering 90% of the functional health facilities, exceeding the minimum target of 80% (*16*)
Supply chain workforce	• Assigned critical staff to operate the emergency supply chain functions (<15% of total workforce) • Implemented motivated policy • Provided a safe and suitable work environment • Updated job descriptions and standard operating procedures • Implemented effective rewarding systems • Adapted the performance management system	• NMSF continued its training programmes and staff empowerment in regional hubs and accessible states • Training courses were conducted for more than 400 employees by the NMSF critical staff and directors of state branches, who were trained and qualified through the programme for strengthening and developing the health supply workforce that the NMSF has implemented since 2011
Information system	• Developed an Excel-based tracker and a paper-based logistics management information system • Established basic inventory software at central Port Sudan • Established the new data centre at Port Sudan • Upgraded network infrastructure • Introduced multiple communication channels including SMS, voice messages, and WhatsApp • Introduced a disaster recovery mechanism	• 76% of states and hubs submitted complete reports (inventory control, financial and received reports) to the central level. The result was below the 90% standard due to several reasons, including disruption of the communication system, instability and displacement of health supply cadre, and security issues.

NMSF = National Medical Supplies Fund; UNDP = United Nations Development Programme

ate outcomes, achieved through resilience of the public health supply chain (Table 2).

FMOH and NMSF responded rapidly and effectively to mitigate the negative impact of the war on vulnerable populations, by adopting strategies to strengthen the health supply chain resilience. These strategies were consistent with the literature on supply chain management and emergency response, and health system resilience as recommended by international organisations (*20*,*21*).

Studies have shown that war-affected countries like Ethiopia, Nigeria, Syrian Arab Republic, Ukraine, and Yemen have adopted strategies similar to those used by Sudan to ensure sustainability and resilience of their health supply chains. These strategies include diversification, e.g. Nigeria's decentralised drug supply, organised logistics hubs in Ukraine's neighbouring countries; cooperation, e.g. Yemen's partnerships to address critical health needs; and functional strategies, e.g. Ukraine's supply chain digitalisation) (*22*–*25*).

Sudan is classified as a low-income country and is included in the list of fragile and conflict-affected situations (*26*). Such countries are exposed to sudden shock and compounding stressors on health systems, which increase the need to implement resilience interventions and strategies (absorption, adaptation and transformation) to maintain continuity of planned, essential health services (*27*). Low- and middle-income countries are vulnerable, lack resilience and face challenges in their health supply chain (*28*). These challenges include weak strategic planning and management, lack of clarity of roles and authority, underfunding, weak data management systems, low human resource capacity and capability, and absence of emergency supply chain protocols (*28*,*29*). NMSF considered these challenges when developing its strategies to strengthen the health supply chain resilience. The strategies did not focus only on the contingency and response phases, they included the recovery and transformative phases to improve prioritisation, planning, risk mitigation, and more effective supply chain performance (*30*).

Effective management of the supply crisis by NMSF senior management, directors of NMSF state branches and dedicated committees helped to significantly mitigate the initial shock, and facilitated redistribution and allocation of resources, especially in remote and affected states. Recent experience suggests that resource allocation and redistribution are important to ensure that remote areas can meet their medical products needs. Compared with single centre efforts, regional and national multidisciplinary teams are stronger for emergency and disaster management, medical shortage response, and risk mitigation (*30*).

One of the key factors that contributed to resilience in Sudan's health supply chain was the reform and investments made over the past 14 years to establish NMSF branches in 17 states (*6*). Despite the challenges of the war, NMSF continued its investments in strengthening supply chain capacity and infrastructure. Such investment chains are essential for increased resourcing of health systems and resilience during pandemics, climate crisis, conflicts, and economic pressures (*31*). A study by the Organisation for Economic Co-operation and Development showed that during the COVID-19 pandemic, underinvestment in the health sector was one of the 3 major vulnerabilities, in addition to underprepared and understaffed health systems. The study recommended national, regional and global investment areas to improve the resilience of health systems before, during and after a crisis, including health promotion and disease prevention, health workforce, health information systems for better decision-making, and infrastructure (*32*).

Local pharmaceutical manufacturing plays an important role in enhancing the resilience and sustainability of medicine supply. To achieve this, policies and reforms must be implemented, particularly given that all pharmaceutical manufacturers have concentrated in the Sudanese capital. The government should support a decentralised production strategy, to encourage and strengthen local pharmaceutical manufacturers through different mechanisms such as providing grants and loans, exemption from taxes, facilitating transfer of drug manufacturing technology from developed countries to local manufacturers, providing foreign exchange to enable local manufacturers to purchase raw materials, setting guidelines for local pricing to ensure affordability for patients, and facilitating international cooperation for the development and increase of local production (*33*,*34*).

Despite the resilience strategies implemented by FMOH and NMSF, this study revealed several weaknesses that should be addressed. The overall availability of essential medicines is still lower than the 80% target set by WHO, including generics to treat major noncommunicable diseases (*35*). There is insufficient funding for emergency and there are difficulties in securing continuous supply and flow of information in the Darfur states due to complex challenges such as insecurity and a complicated political situation.

Table 3 highlights the key lessons from the NMSF response during the war in Sudan.

Conclusion

Sudan's health supply chain has achieved remarkable resilience despite the complex war challenges. The strategies and interventions adopted during the crisis have strengthened the performance of NMSF, supported the rapid response, reduced the negative effects of the war, and facilitated the delivery of essential health products across the country. This study could be used as baseline information for further research on strategies related to health supply chain resilience in Sudan. Although achievements have been made in managing the supply chain, the challenges of the war require that NMSF continues to assess the health supply chain resilience, especially from different perspectives, such as those of

Table 3 Lessons learned from National Medical Supplies Fund response during the war in Sudan

Domain	Lesson learnt
Leadership and political commitments	Strengthen governance and provide clearer leadership of the supply chain
	Prompt implementation of emergency, contingency and strategic plans
	Improve visibility and performance of the health supply chain
Flexibility in response	Creates success during crisis
	Facilitate flexibility in procurement mechanisms
	Rapid redirection of resources to the most needed areas
Excellence in managing human resources	Improve the supply chain performance
	Qualified and well-trained staff continue the training programmes during a crisis
Regional storage and distribution hubs	Contributes to the rapid response to health needs
	Improves accessibility in war-affected states
	Optimises storage space
Adopting distribution model	Use of alternative distribution routes (e.g. air, drones and riverine transport)
	Maintain the flow of essential health products
International organizations and donor support	Strengthen the supply chain capacity and infrastructure
	Unpredictable to secure sufficient and sustainable funding

health providers and communities. Since resilience is a continuous process, we recommend sustained proactive actions, support, commitment, innovative solutions, and collaboration between NMSF and its local and international stakeholders to improve the resilience of Sudan's health supply chain. Efforts should include mobilising funds, technical support, digital solutions, and policy advocacy to overcome supply chain disruptions and support long-term recovery.

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References

1. United Nations. Sustainable Development Goals: Goal 3 – Good health and well-being. New York: UN, 2024. https://www.un.org/sustainabledevelopment/health/.
2. Mhazo AT, Maponga CC. Framing access to essential medicines in the context of universal health coverage: a critical analysis of health sector strategic plans from eight countries in the WHO African Region. BMC Health Serv Res. 2022;22(1):1390. https://doi.org/10.1186/s12913-022-08791-9.
3. Ozawa S, Evans DR, Bessias S, Haynie DG, Yemeke TT, Laing SK, et al. Prevalence and estimated economic burden of substandard and falsified medicines in low- and middle-income countries: A systematic review and meta-analysis. JAMA Netw Open. 2018;1(4):e181662. https://doi.org/10.1001/jamanetworkopen.2018.1662.
4. World Health Organization. Universal health coverage. Geneva: WHO, 2024. https://www.who.int/health-topics/universal-health-coverage#tab=tab_2.
5. Federal Ministry of Health. The national supply chain strategy for pharmaceuticals and health products. Khartoum: Federal Ministry of Health, 2017. https://www.nmsf.gov.sd/includes/pdf/UNDP_NCSS.pdf.
6. National Medical Supplies Fund. Reform of the national health supply chain in Sudan: achievements, challenges, success factors and lessons learned, 2nd edition. Khartoum: NMSF, 2015. https://www.nmsf.gov.sd/library/87.
7. Makkawi AME, Mousnad MA, Mohamed GK. Cost-effectiveness analysis of supply chain system: Sudan's National Medical Supplies Fund 2011–2014. Glob J Qual Saf Healthc. 2020;3(2):72–80. https://doi.org/10.36401/JQSH-20-6.
8. Data Friendly Space. Sudan crisis situational analysis. Williamsburg, VA, 2023. https://www.datafriendlyspace.org/resources/sudan-crisis-situational-analysis-18-december-2023.
9. World Health Organization. Public health situation analysis: Sudan conflict, April–August 2024. Geneva: WHO, 2024. https://www.who.int/publications/m/item/public-health-situation-analysis--sudan-conflict-%2820-august-2024%29.

10. National Medical Supplies Fund. Sudan national humanitarian response, reform and recovery supply chain strategy for pharmaceuticals and health products, 2024–2028. Khartoum: NMSF, 2024. https://www.nmsf.gov.sd.
11. National Medical Supplies Fund. Sustainability and resilience of the national health supply chain during the Sudan War: strategic actions, achievements, and lessons learned, 2023–2025. Khartoum: NMSF, 2025. Unpublished report.
12. World Health Organization. Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies. Geneva: WHO, 2010. https://iris.who.int/bitstream/handle/10665/258734/9789241564052-eng.pdf.
13. World Health Organization. Health system resilience indicators: an integrated package for measuring and monitoring health system resilience in countries. Geneva: WHO, 2024. https://www.who.int/publications/i/item/9789240088986.
14. Zimmermann J, McKee C, Karanikolos M, Cylus (editors). Strengthening health systems: a practical handbook for resilience testing. Copenhagen: WHO Regional Office for Europe, 2024. https://eurohealthobservatory.who.int.
15. Therrien M, Normandin J, Denis J. Bridging complexity theory and resilience to develop surge capacity in health systems. J Health Organ Manag. 2017;31(1):96–109. https://doi.org/10.1108/JHOM-04-2016-0067.
16. Sphere Association. The Sphere handbook: humanitarian charter and minimum standards in humanitarian response 4th ed. Geneva: Sphere Association, 2018. https://spherestandards.org/handbook.
17. World Health Organization. Harmonized monitoring and evaluation indicators for procurement and supply management systems: early-warning indicators to prevent stock-outs and overstocking of antiretroviral, antituberculosis and antimalaria medicines. Geneva: WHO, 2011. https://www.who.int/publications/i/item/9789241500814.
18. The Global Fund to Fight AIDS, Tuberculosis and Malaria. Modular framework handbook: allocation period 2023–2025. Geneva: The Global Fund, 2022. https://www.theglobalfund.org/media/4309/fundingmodel_modularframework_handbook_en.pdf.
19. Mohamed Ali G. Medical supplies agencies and access to foreign currency in resource-limited settings: case studies from Sudan. East Mediterr Health J. 2022;28(1):74–77. https://doi.org/10.26719/emhj.22.004.
20. World Health Organization. Building health system resilience to public health challenges: guidance for implementation in countries. Geneva: WHO, 2024. https://www.who.int/publications.
21. United States Agency for International Development. Best practices in supply chain preparedness for public health emergencies. Washington: USAID, 2019. https://www.ghsupplychain.org/best-practices-supply-chain-preparedness-public-health-emergencies.
22. Ammar W, Kdouh O, Hammoud R, Hamadeh R, Harb H, Ammar Z, et al. Health system resilience: Lebanon and the Syrian refugee crisis. J Glob Health. 2016;6(2):020704. https://doi.org/10.7189/jogh.06.020704.
23. Ager AK, Lembani M, Mohammed A, Ashir GM, Abdulwahab A, de Pinho H, et al. Health service resilience in Yobe state, Nigeria in the context of the Boko Haram insurgency: a systems dynamics analysis using group model building. Confl Health 2015;9(1):30. https://doi.org/10.1186/s13031-015-0056-3
24. Management Sciences for Health. Ukraine's investments in digitizing its health supply chain are saving lives during the war. Arlington, VA: MSH, 2023. https://msh.org/story/ukraines-investments-in-digitizing-its-health-supply-chain-are-saving-lives-during-the-war/.
25. Chol C, Negin J, Garcia-Basteiro A, Gebregzabher Gebrehiwot T, Debru B, et al. Health system reforms in five sub-Saharan African countries that experienced major armed conflicts (wars) during 1990–2015: a literature review. Glob Health Action 2018;11(1):1517931. https://doi.org/10.1080/16549716.2018.1517931.
26. World Bank. FY24 list of fragile and conflict-affected situations. Washington: World Bank, 2024. https://thedocs.worldbank.org/en/doc/608a53dd83f21ef6712b5dfef050b00b-0090082023/.
27. Truppa C, Yaacoub S, Valente M, Celentano G, Ragazzoni L, Saulnier D. Health systems resilience in fragile and conflict-affected settings: a systematic scoping review. Confl Health 2024;18(1):2. https://doi.org/10.1186/s13031-023-00560-7.
28. Duwiejua M, Steele P, Lalvani P, Leab D, Matowe L, Moody J. Promising practices in capacity development for health supply chains in resource-constrained countries. Glob Health Sci Pract. 2024;12(Suppl 3):e2300208. https://doi.org/10.9745/GHSP-D-23-00208.
29. Pradhan NA, Samnani AABA, Abbas K, Rizvi N. Resilience of primary healthcare system across low- and middle-income countries during COVID-19 pandemic: a scoping review. Health Res Policy Syst. 2023;21:98. https://doi.org/10.1186/s12961-023-01031-4.
30. National Academies of Sciences, Engineering, and Medicine. Building resilience into the nation's medical product supply chains. Washington: National Academies Press, 2022. https://doi.org/10.17226/26420.
31. Rasanathan K. How can health systems under stress achieve universal health coverage and health equity? Int J Equity Health 2024;23(1):244. https://doi.org/10.1186/s12939-024-02293-2.
32. Organisation for Economic Co-operation and Development. Ready for the next crisis? Investing in health system resilience. Paris: OECD Publishing, 2023. https://doi.org/10.1787/1e53cf80-en.
33. Dong J, Mirza Z. Supporting the production of pharmaceuticals in Africa. Bull World Health Organ. 2016;94(1):71–72. https://doi.org/10.2471/BLT.15.163782.
34. World Health Organization. Local production for access to medicinal products – developing a framework to improve public health. Geneva: WHO, 2011. http://www.who.int/phi/publications/local_production/en/.
35. World Health Organization. Global action plan for the prevention and control of noncommunicable diseases 2013–2020. Geneva: WHO, 2013. https://www.who.int/publications/i/item/9789241506236.