


Article

Dualism of the Health System for Sustainable Health System Financing in Benin: Collaboration or Competition?

Calixte Bidossessi Alakonon^{1,*}, Josette Rosine Aniwuvi Gbeto², Nassibou Bassongui¹ 
and Alastair Sèna Alinsato¹

¹ Laboratoire d'Économie Publique, Université d'Abomey-Calavi, Cotonou 04 BP 966, Benin; bionassib@gmail.com (N.B.); alastair.alinsato@uac.bj (A.S.A.)

² Département d'Économie, Université de Laval, Québec, QC G1V 0A6, Canada; josette-rosine-aniwuvi.gbeto.1@ulaval.ca

* Correspondence: alakononcalixte@gmail.com

Abstract

This study analyses the conditions under which co-opetition improves the supply of health-care services in Benin. Using non-centralised administrative data from a sample of public and private health centres, we apply network theory and negative binomial regression to assess the extent to which competition affects collaboration between public and private healthcare providers. We found that competition reduces the degree of collaboration between private and public health providers. However, the COVID-19 pandemic significantly mitigated this effect, highlighting the potential for competition within the healthcare system without compromising social welfare. Notwithstanding that, we show that these benefits are not sustained over time. These findings have policy implications for the sustainability of health system financing in Africa, particularly by promoting sustainable financial mechanisms for the private sector and more inclusive governance structures.

Keywords: dualism; health system financing; collaboration; competition; COVID-19; Benin

JEL Classification: I11; L1



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1. Introduction

Establishing a healthcare system to provide services to all populations is a paramount concern for all governments, especially in developing countries. This is due to the significance of healthcare scale relative to the gross domestic product (GDP) and its impact on population well-being (Herrera-Araujo & Rochaix, 2020). The Sustainable Development Goals (SDG3) envision universal health coverage, encompassing financial risk protection and access to quality essential health services, as well as safe, effective, quality, and affordable essential medicines and vaccines at an accessible cost. Achieving this goal necessitates a well-performing health system to ensure the adequate provision of healthcare services. In developing countries, individuals typically lack health insurance, possess low purchasing power, exhibit low health literacy, and reside in underserved areas. These factors present significant obstacles, resulting in limited access to healthcare services. Moreover, public health centres often fail to provide adequate healthcare services due to insufficient state resources and inefficiencies within the public health system itself (Bhattacharyya et al., 2010; Rangan et al., 2007). Consequently, in response to this inadequacy in public healthcare provision, there has been a proliferation of private healthcare services across countries in recent decades. This trend has seen a substantial influx of private, for-profit companies into the healthcare

service market. As a result, healthcare systems in countries have evolved into hybrids, where collaboration or competition between public and private health centres is observed, with the latter seeking to maximise profit in the provision of healthcare services to populations.

In the economic literature, it is postulated that the collaborative and competitive behaviours of health system actors generate specific advantages in the provision of health services to populations (Mascia et al., 2012). Collaboration between private and public health centres allows for more efficient use of resources, facilitates access to information and clinical expertise, and leads to the achievement of common objectives (Provan & Milward, 1995; Alter, 1990). Additionally, improving the level of collaboration between healthcare providers positively influences the quality-of-care delivery, operational efficiency, and financial performance (Trinh et al., 2010; Chukmaitov et al., 2009; Clement et al., 1997). Similarly, other research shows that competition between public and private health centres determines the level of costs, access, and quality of healthcare services (Brekke et al., 2021; Kessler & Geppert, 2005). The literature indicates that competition forces health centres to innovate and become more efficient in a context where the prices of healthcare services are regulated and the quality is observable, which can guide the demand for healthcare services. This leads to lower prices for services and improves the quality of healthcare (Cooper et al., 2018; Barros et al., 2016; Cookson et al., 2013). Thus, individual, collaborative, and competitive behaviours between private and public actors contribute to improving the performance of the country's health system.

Another strand of the literature argues that the presence of competitive behaviour between private and public healthcare providers can harm the degree of collaboration between the two systems because the fear of direct competition keeps companies away from similar competitors. Thus, based on the advantages of collaboration differences that bring companies closer to similar competitors, changes in the degree of competition in the health system can strengthen collaboration between public and private health centres (Baum & Haveman, 1997; Freeman & Hannan, 1983; Cohen & Levinthal, 1990). However, other studies showed that the competition between the private and the public sector does not influence the cooperation between the two health systems. Recall that the collaboration between health centres is determined by the complementarity of resources, the differentials in the volume of activity, the organisational performance, and the distance between them (Mascia et al., 2012). Indeed, when competition negatively impacts collaboration, it induces harmful consequences for the provision of health services, compromising the overall performance of the health system (Naamati Schneider, 2021; Barros et al., 2016). This highlights that the lack of collaboration due to competition among health centres is detrimental to the health system. Based on this literature, the authorisation of private health centres' intervention by public authorities must undergo a thorough and explicit examination of the obstacles to healthcare service provision. Additionally, an analysis of how the provision of private health centres can mitigate obstacles and enhance the health system's performance is necessary (World Health Organization, 2000). Consequently, controversy surrounds the cohabitation of public and private healthcare sectors to strengthen the performance of the health system in sub-Saharan countries.

Like all countries, Benin faces a growing demand for health services due to population growth and health crises. Estimates from the National Institute of Statistics and Demography (INStAD) show that the total population of the Republic of Benin was 11,884,127 inhabitants in 2019, with an annual intercensal increase of 3.5%. Despite definite improvements, Benin's health situation is still characterised by high general and specific mortality rates. According to the fifth Demographic and Health Survey in Benin (ICF, 2019), the infant mortality rate for the five-year period before the survey is estimated at 55 per 1000 live births. Nationally, the infant and child mortality rates are 96 per 1000 live births, meaning

approximately one in ten children does not reach their fifth birthday. This is significantly higher than the 25 per 1000 live births rate targeted for achievement by 2030 under SDG3. Additionally, for maternal mortality, Benin is at a rate of 391 deaths per 100,000 live births, which is still far from the target of 70 per 100,000 live births set by 2030 under SDG3 (ICF, 2019). Regarding the supply of health services, the Beninese health system has witnessed an increasing rate of entry of private health centres into healthcare provision. According to SNIGS (2019), the number of private health centres (441) is almost half the number of public health centres (912). This may lead to the possibility of competition between the two healthcare service delivery systems.

To improve the performance of the Beninese health system, governments have adopted several measures to enhance collaboration between public and private health centres. Currently, there is a consultation framework between the public and private sectors. Health statistics in Benin indicate that the country remains one of the most vulnerable countries in terms of health, especially amidst the COVID-19 crisis. Therefore, it is essential to examine the dualism of the health system to guide health policy measures promoting collaboration and competition between public and private health centres to enhance the health system's performance. The primary question underlying this study is the extent to which strategic relationships between private and public health centres influence healthcare provision in Benin. Indeed, previous studies in Africa have mainly focused on public–private partnerships for hospital management or the delivery of health service infrastructure, rather than on analysing market structure (Mwakapala & Sun, 2020; Salangwa et al., 2025; Meessen et al., 2011). Mwakapala and Sun (2020) analysed the sustainability of public–private partnership (PPP) implementation in Tanzania. Using a mediating model, they concluded that the success and sustainability of PPP implementation depend on the quality of governance. More recently, Salangwa et al. (2025) conducted a case study to analyse how public–private partnerships (PPPs) affect health service delivery in Malawi. Using data collected from Christian Health Association of Malawi (CHAM) facilities in Mzimba District, they highlighted that government officials acknowledged the positive impact of PPPs on healthcare access, particularly in rural areas, but raised concerns about sustainability due to policy inconsistencies, financial instability, and duplication of services. Meessen et al. (2011) previously examined the effectiveness of removing user fees in the health sector across six sub-Saharan African countries: Burkina Faso, Burundi, Ghana, Liberia, Senegal, and Uganda. Their findings showed that the reform fell short of expected outcomes due to rushed and poorly prepared implementation, as well as limited consultation with various stakeholders. This highlights the need for reform processes to be supported by adequate funding, long-term commitment, and careful planning. Beyond the continent, De Matteis et al. (2024) used text mining techniques from the existing literature to study the determinants of the sustainability of the public–private partnerships in the healthcare sector. The authors highlighted core areas of sustainability, notably a balanced governance structure integrating public and private entities alongside community and stakeholder voices, the technical and managerial competencies of the stakeholders, and the role of Big Data. Tabrizi et al. (2020) conducted a systematic review of 108 articles focusing on low- and middle-income countries. Their findings indicate that public–private partnerships (PPPs) led to significant improvements across various healthcare domains, notably in access to services, economic benefits, and enhancements in quality of service. These results were consistent across both quantitative and qualitative studies.

This research question was addressed through three objectives: (i) estimate the degree of collaboration between public and private health centres, (ii) estimate the degree of competition between public and private health centres, and (iii) evaluate the effect of competition on the level of collaboration between the two health systems in Benin.

This paper fills a gap in the literature, especially in the Beninese context, allowing for an assessment of how competition between health centres affects the degree of collaboration. The policy implications of this study are twofold. Firstly, it has implications for the funding of the health system in Africa and Benin, as it may guide policymakers to promote public–private partnerships (PPPs) in the healthcare provider system. African countries are characterised by low levels of tax resource mobilisation, resulting in persistent budget deficits and a lack of resources to finance public goods such as public infrastructures in the health and education sectors. Thus, promoting PPPs in the health sector will complement the scarcity of public healthcare supply, increasing the health system’s resilience to potential shocks such as COVID-19. Secondly, beyond healthcare service availability, this study has implications for the demand side of healthcare services. In particular, private sector participation will create competition, leading to a decrease in the cost of healthcare services. In a context where African countries face difficulties in building a health insurance system due to budget constraints, the cohabitation of private and public healthcare providers will increase access to healthcare services.

The rest of the paper is organised as follows. Section 2 presents an overview of Benin’s health pyramid and healthcare provision system. Section 3 presents the literature review. The conceptual framework is presented in Section 4. In Section 5, we present the methodology and data used. The main findings are presented and discussed in Section 6. Lastly, the concluding remarks are presented in Section 7.

2. Health Pyramid and Healthcare Supply in Benin

Benin’s healthcare supply is characterised by a cohabitation of public and private health centres. Both healthcare suppliers depend on the same health administration authority. Benin has relied on the three-phase healthcare development scenario adopted by the World Health Organization (WHO) for Africa in 1985. Benin’s healthcare system is structured on administrative divisions at three levels: the central or national level, the intermediate or departmental level, and the peripheral or health zone level (Decree 426 of 20 July 2016, and Decree No. 2022-148 of 2 March 2022).

According to this organisation, at the national level, the Ministry of Health is responsible for designing, implementing, monitoring, and evaluating the state’s health policy by the laws and regulations in force in Benin and the government’s visions and development policies. The intermediate level comprises the twelve Departmental Health Directorates (DDS) and second-level health structures, which are responsible for implementing the government’s health policy, planning and coordinating all health service activities and ensuring epidemiological surveillance in the 12 administrative regions. Finally, the peripheral level constitutes the foundation of the healthcare pyramid and consists of 34 health zones. According to Decree 98-300 of 28 September 2005, which reorganises the healthcare pyramid, a health zone is the most decentralised operational entity of the healthcare system intended to serve an area with a population of between 100,000 and 200,000 inhabitants. It is organised as a network of primary public contact services (only maternity and dispensaries, health centres) and private healthcare facilities, all supported by a public or private first-level referral hospital called a zone hospital. Considering this organisational framework, the healthcare pyramid includes primary-level structures (dispensaries, health centres. . .), reference structures (zone hospitals), specialised structures (dedicated to disability or disease), and hospital-university centres at the central and intermediate levels. Thus, a system of reference and counter-reference is adopted in Benin between the different levels of the healthcare system to provide quality care. Therefore, a form of collaboration exists between public and private hospitals, where they can exchange patients, medical equipment, and expertise. This collaboration is particularly reinforced by the actions of the

coordination framework between public and private hospitals created by Decree No. 4139 of 13 May 2005. Notably, actions such as strengthening the skills of private healthcare personnel in infection prevention and patient care have been initiated.

However, the collaboration between public and private hospitals is not always optimal in promoting the effective provision of healthcare services. Private hospitals, being primarily motivated by profit, engage in competitive actions to gain a larger market share. In this regard, it is observed that employees of public hospitals working in private hospitals redirect patients to their private hospitals, which becomes detrimental to the performance of the healthcare system. Therefore, the government regulated the health sector in 2018 through Decree No. 2018-342 of 25 July 2018, which suspends the issuance and revokes the authorisation for medical or paramedical professionals employed as public servants to practice in the private sector. This context highlights the importance of investigating the nature and dynamics of the collaboration between public and private health centres to guide more effective health policies for better performance in the increasingly crisis-ridden healthcare sector.

3. Literature Review

The analysis of interactions between public and private health centres in the provision of healthcare services is a concern in the economic literature. These studies seek to examine the existence of collaboration or competition between public and private health centres.

3.1. Competition Effects

In a hybrid healthcare system, the degree of competition can affect the collaboration between public and private health centres, which can impact the efficiency of the country's health system (Brekke et al., 2021; Naamati Schneider, 2021; Barros et al., 2016; Trinh et al., 2010; Chukmaitov et al., 2009). Focusing on hospitals in a single Italian region, Mascia et al. (2012) showed that productivity decreases with competition but improves with collaboration, especially when hospitals form cooperative networks that mitigate competitive effects. Equally, Vilar-Rodríguez and Pons-Pons (2019) analysed competition and collaboration between the public and private sectors of the Spanish health centre system and concluded that a dual healthcare system provider could lead to an absence of collaboration between private and public health centres depending on the quality of political governance.

Stašys et al. (2021) studied health centre transfers and partnerships in New South Wales, Australia. They used health centre administrative data for discharges from all acute care health centres from 1 July 2013, to 30 June 2015. In addition, patient discharge and admission information were used to identify inter-health centre transfers. The results of the descriptive analysis showed that transferred patients accounted for 3.9% of all NSW admitted patients, and overall, 7.3% of NSW admissions were associated with transfers. Importantly, patients were more often transferred to larger health centres than to smaller health centres (61% vs. 29%). Compared to private health centres, public health centres had a higher rate of inter-health centre transfers (8.4% vs. 5.1%) and a greater proportion of Inter-Health centre transfers (52% vs. 28%). Large public health centres had lower inter-health centre transfer rates (3–8%) compared to small public health centres (13–26%). Large public health centres received and transferred higher proportions of inter-health centre patients (52–58% and 11%, respectively) than their smaller counterparts (26–30% and 2–3%, respectively). They also find that less than a quarter of the inter-health centre transfers were between the public and private sectors or between government health regions.

3.2. Collaboration Benefits

Studies highlighted the positive impacts of collaboration among health centres and public health actors, particularly in terms of service quality, patient outcomes, and organisational performance across various healthcare systems. Thus, [Berta et al. \(2022\)](#) investigated the determinants of health centre collaboration in Italy. Through a large administrative dataset, the authors used network and Poisson mixed analyses to find a positive association between collaboration and quality-of-service delivery. Along the same lines, [Lomi et al. \(2014\)](#) examined inter-health centre collaboration through the dynamics of patient-sharing relationships within an Italian regional community of 35 health centres serving approximately 1,300,000 people over the period 2005–2008. Using reconstruction of the complete temporal sequence of consecutive inter-health centre patient sharing events and estimation of newly derived models for relational event sequences, the results showed that patients flow from less performing health centres to more competent health centres. [De Pourcq et al. \(2019\)](#) conducted a systematic review of 42 studies to examine the role of governance in interhospital collaborations. They found that effective, context-sensitive governance, characterised by shared goals, transparency, and stakeholder inclusion, was essential to collaboration success across models such as networks, mergers, and alliances in diverse healthcare systems. Furthermore, [Halverson et al. \(2000\)](#) analysed how organisational factors and market conditions influence collaboration between public health agencies and healthcare providers in 60 U.S. counties, using survey data and multivariate analysis. They found that collaboration was more likely in areas with managed care penetration, strong leadership, and supportive governance structures.

3.3. Co-Opetition in Healthcare

Studies explored the complex interplay between collaboration and competition, commonly referred to as co-opetition, within healthcare systems, drawing on dynamic analyses that reveal how competitive pressures can coexist with, and even reinforce, cooperative relationships among providers. [Mascia et al. \(2012\)](#) conducted a dynamic analysis of inter-health centres' collaboration and competition in the Italian regional health system, determining how the increasing competition between health centres is related to their propensity to collaborate with other local providers. They utilised longitudinal data on inter-health centre collaboration and competition collected in an Italian region from 2003 to 2007. Using social network analysis techniques, the authors studied the structure and dynamics of inter-health centres' collaboration. Next, negative binomial regressions were employed to explain the influence of inter-health centres' competition on the collaborative networks over time. Their results showed that competition between providers did not hinder the inter-health centres' collaboration. Additionally, they indicated that the collaboration is essentially local and depends on the complementarity of resources, differentials in the volume of activity, and health centre performance.

Given this literature, it is worth noting that a dual healthcare system can lead to competition between private and public health centres, collaboration between private and public health centres, or both competition and collaboration between private and public health centres. However, the existing literature is silent about the conditions under which collaboration could jointly exist with competition. More importantly, to the best of our knowledge, no empirical research work has focused on the analysis of collaboration and competition between public and private health centres in African countries in general, and in Benin. Previous studies have mainly focused on public–private partnerships for hospital management or the delivery of health service infrastructure, rather than on analysing market structure ([Mwakapala & Sun, 2020](#); [Salangwa et al., 2025](#); [Meessen et al., 2011](#)). Under the devastating consequences of the COVID-19 crisis on healthcare systems, this

work is relevant to guiding policymakers to build a resilient healthcare system in which both private and public health centres operate to tackle any pandemic. Hence, this study is rooted in microeconomics literature on market structure. However, our focus is on exploring the relationship between competition and collaboration, rather than the more traditional competition-monopoly dynamic. Although akin to the competition-monopoly relationship, the contrast between competition and collaboration is not straightforward. While neoclassical theory posits that competition and collaboration are conflicting, another strand in the literature suggests that they can coexist. This phenomenon is commonly known as co-opetition (Brown, 1996) and group-based competition (Zey, 1997). The distinction between these new forms of competition lies in co-opetition occurring within the network and group-based competition happening between groups. Both co-opetition and group-based competition are characteristic of our study framework, where private hospitals may compete among themselves and with public hospitals. These alternative forms of competition highlight that competition does not necessarily preclude collaboration. Suppliers' rational behaviour, aiming to save operating costs and spread risks, contributes to this nuanced relationship.

4. Conceptual Framework

The effect of competition on health centres' collaboration was guided by a conceptual framework as depicted in Figure 1. From this figure, we assume that competition may affect the degree of collaboration through two main channels, an increase in resource scarcity and an increase in health centre diversities. Firstly, competition creates a scarcity of health centres' resources, namely "patients". Consequently, while these resources are crucial for the survival of health centres, they may lead to a decrease in the likelihood of collaboration between private and public health centres. Conversely, due to the heterogeneity of health centres in specialties, volume and timing of activities, and medical equipment, this would lead to an increased need for collaboration between private and public health centres.

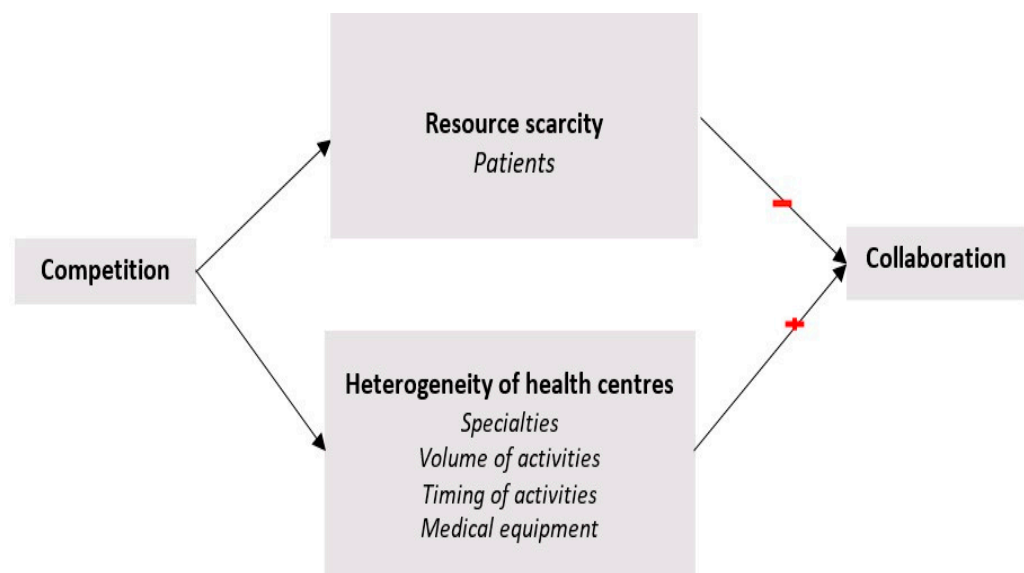


Figure 1. Conceptual framework. Source: Authors' conception, 2023.

5. Methodology

This study is based on administrative data from health centres. The unit of observation is healthcare providers in Benin. Specifically, we focus on the administrative department of Atlantic, the most populous department of Benin, with its capital city being Abomey-Calavi. This department accounts for 1,614,229 people, representing 14% of the Benin

population (RGPH, 2015). Before presenting our empirical strategy, we calculated the sample size for the study. It is important to note that while relying on administrative data, it is crucial to acknowledge that the data was not centralised. Consequently, it necessitated manually compiling all the required data for this study for all the health centres. Due to limitations in time and budget, it was unfeasible to undertake such a task for all the health centres in Benin or even for those within the specific administrative department targeted Atlantic. Hence, we opted for a randomised sampling strategy to address the constraints and determine the number of health centres to be included in the study.

5.1. Sampling

The sample size is calculated based on official data from the latest 2018 Health Statistical Yearbook of the Ministry of Health. The data from this yearbook are used to obtain the size of health centres, the distribution of health centres in health zones, and according to the public/private specification to make a proportional and representative allocation of primary sampling units (PSUs) in the sampling strategy. The approach used is one that defines a probability sample. Given the small size of our PSU, which consists of 212 health centres. Following Cochran (1977), the sample size for a finite population was determined as:

$$n_k = \frac{n_0}{1 + (n_0 - 1)/N_k} \tag{1}$$

where $n_0 = pqZ^2/e^2$ and n_k is the sample size in the region k , p is the prevalence of the topic investigated. To consider non-responses, we adjust this later by 10%. This parameter was chosen based on the existing literature (Mascia et al., 2012), and q equals $1-p$, e measures the level of precision, Z is the abscissa of the normal distribution that equals 1.96 for 95% confidence level.

Then we have:

$$n_k = \frac{0.05(1 - 0.05) * 1.96 * 1.96}{0.05 * 0.05} = 73$$

and

$$n_k = \frac{73}{1 + (73 - 1)/212}$$

Applying this formula to the three administrative health areas (Abomey-Calavi-So-ava, Ouidah-Kpomassè-Tori Bossito and Allada-Toffo-Zè) for the department of Atlantic chosen for this study, we obtain the total number of health centres we survey by area. Table 1 gives the details of the sample, where 34 private health centres and 26 public health centres are surveyed.

Table 1. Sample size.

Health Administrative Area	Private	Public	Total
Abomey-Calavi-So-ava	$92 \times 55/212 = 24$	$23 \times 55/212 = 6$	30
Ouidah-Kpomass'e-Tori-Bossito	$36 \times 55/212 = 4$	$14 \times 55/212 = 9$	13
Allada-Toffo-Z'e	$35 \times 55/212 = 3$	$12 \times 55/212 = 9$	12
Total	31	24	55
Adjusted for 10% non-responses	34	26	60

Source: Authors' calculations, 2023.

The sampling strategy employed is a multistage stratified probability sampling strategy. The principle of this method is to ensure that everyone in the study population has an equal and known chance of being selected for inclusion in the sample. In practice, this entails (a) applying random selection methods at each sampling stage and (b) sampling with a probability proportional to the population size. The study population is stratified

by two characteristics, namely public and private health centres. Stratification reduces the probability of excluding distinct groups of health centres from the sample. Consequently, the sample is distributed in proportion to the weight of each city department's population in the national population. Directory data was utilised to calculate the weight of each department. This weight, when multiplied by the sample size, provides the sample size by health zone. The same process is used to determine the sample size by the public/private nature.

5.2. Empirical Strategy

To achieve the objectives of this project, we employed a quantitative approach. Our empirical strategy was predicated on the assumption of the existence of a one-way referral system from private to public health centres. This assumption was based on the provisions of DECREE No. 2022-148, dated 2 March 2022, which organises the health pyramid in the Republic of Benin.

5.2.1. Investigating the Degree of Collaboration and Competition Between Public and Private Health Centres in Benin

To fulfil this primary objective, we adopted the methodology used by [Mascia et al. \(2012\)](#) and [Sohn \(2002\)](#). Initially, we collected data on patients transferred between the 60 selected health centres from their registries. Before fieldwork commenced, we incorporated a 60×60 table into the digital questionnaire, listing all the selected health centres in rows and columns. With this table, we gathered information on the total number of patients referred by each health centre in the row to the health centres in the column for the years 2019, 2020, and 2021. Subsequently, we created a 34×26 matrix, with private health centres in rows and public health centres in columns. This matrix provided data on the number of patients transferred from private health centre i ($i = 1$ to 34) to public health centre j ($j = 1$ to 26). Using this information, we established directed edges (or links) of a health centre network, representing connections between the nodes (health centres) of the network and signifying referrals from one health centre to another. These directed edges resulted in a total of 884 links (observations), each with its degree representing the number of patients shared between a pair of private and public health centres. Patient sharing serves as a key measure of collaboration between health centres, facilitating coordination of activities across boundaries ([Mascia et al., 2012](#)).

To assess the level of competition between health centres, we employed a relational approach developed by [Sohn \(2002\)](#). This approach is grounded in the niche overlap theory and begins by identifying a shared resource on which health centres rely, i.e., patients. It is worth noting that the term "overlap" is drawn from the literature of network economics rather than the microeconomics of market structure. [Sohn \(2002\)](#) utilises it to measure competition.

To illustrate the concept of "overlap," let us consider a hypothetical country denoted as B , with a healthcare system comprising c hospitals (for all $c = 1, \dots, m$), each belonging to a healthcare administrative zone l (for all $l = 1, \dots, n$). Each centre c is expected to admit only patients residing in zone l . An overlap with hospital c occurs if it admits a patient residing in zone k , for all k different from l . Therefore, the presence of competition, indicated by the minimum competition value greater than zero (0.048) in [Table 2](#), implies that each hospital belonging to zone l admitted at least one patient from zone k , for all k different from l , during the observation period. This finding underscores the persistence of competition, with its intensity fluctuating over time and across geographical areas.

Table 2. Degree of collaboration and competition.

	N	Mean	St. Dev.	Min	Max
2019					
Collaboration	884	0.111	0.811	0.000	11
Competition	884	0.823	0.215	0.048	1
2020					
Collaboration	884	0.442	2.211	0.000	36
Competition	884	0.807	0.234	0.06	1
2021					
Collaboration	884	0.365	0.872	0.000	27
Competition	884	0.822	0.220	0.046	1

Source: Authors, from estimates, 2023.

Consequently, the viability of health centres hinges on their patient intake, prompting them to adopt strategies to attract more patients if they are not in a monopolistic situation. In Benin, the department of Atlantic is subdivided into three administrative health areas (Abomey-Calavi-So-ava, Ouidah-Kpomassè-Tori-Bossito, and Allada-Toffo-Zè), and we directly employed these specific geographic areas as the resource niches for health centres. Let x_{ik} denote the total number of patients that the health centre i draws from geographic area k , and x_{jk} represents the total number of patients that health centre j draws from geographic area k . The competition coefficient is the proportion of the total resource niche of health centre i that overlaps with that of health centre j , calculated using the following formula:

$$C_{i,j} = \frac{\sum_k x_{i,k} * \min(x_{i,k}, x_{j,k})}{\sum_k x_{i,k} * x_{j,k}} \quad (2)$$

where the denominator represents the niche size of i , and the numerator represents i 's niche overlapped by j 's. The term $\min(x_{i,k}; x_{j,k})$ ensures that C_{ij} falls between 0 (no overlap) and 1 (complete overlap). This implies an absence of competition between private and public health centres ($C = 0$) and perfect competition ($C = 1$), respectively. This measure of competition has been utilised in previous studies (Mascia et al., 2012; Sohn, 2002; Wong et al., 2005).

5.2.2. Investigating the Influence of Competition on the Degree of Collaboration Between the Two Health Systems in Benin

This objective is pursued through empirical analysis. Since our main dependent variable (Collaboration) is count data, we employ a count data model to estimate the effect of competition on the degree of collaboration between the two health systems in Benin. According to Cameron and Johansson (1998), health-utilisation counts are typically (if not always) overdispersed. This was indeed the case in this study, as indicated by a high variance of the collaboration indicator (2.21) over the mean (0.44) in 2020 (see Table 2). Therefore, we employed Negative Binomial regression.

$$\lambda_{ij} = \exp(\phi_{ij}) \quad (3)$$

where $\phi_{ij} = \delta_0 + \delta_1 C_{i,j} + \delta_l X_i + \delta_d X_{i,j} + \delta_k + \epsilon_{ij}$ represents the expected number of patients flowing from health centre i to health centre j . ϕ_{ij} is modelled as a function of C_{ij} , the measure of competition between health centre i and health centre j . The coefficient of interest is δ_1 , which is interpreted as the effect of a unit variation of the monopoly power of private health centres in the system on the level of collaboration between private and public health centres. The expected sign of this coefficient is negative, as ample monopoly power is harmful to collaboration.

We include some covariates X_i and X_{ij} , which represent, respectively, an l-dimensional vector of observed characteristics of private health centres (such as the number of beds, the number of qualified health workers, the number of years of experience, the number of technical laboratories, the number of technical imaging facilities. . .) and a d-dimensional vector of observed dyad-specific variables that are the difference in absolute value between characteristics of health centres and which can affect the likelihood of observing collaboration between health centre dyads. Following the social network literature, there is homophily in link formation, meaning that individuals tend to form relationships with others who have similar attributes (Fowler & Christakis, 2008; Hsieh & Lee, 2016). In the health centre network, this holds, as patient referrals can occur between two health centres depending on the similarity in characteristics of health centres. For example, the variable “Number of beds dyads” is the difference in absolute value between the number of beds of health centre i and the number of beds of health centre j . If the number of bed dyads is greater between two health centres, the health centre with a greater capacity of beds can receive more patients from those with a lower capacity of beds, and vice versa for other attributes of the health centre. δ_k represents geographic area fixed effects, which capture all common factors in the geographic area that can affect collaboration. ϵ_{ij} is an error term assumed to follow a Gamma distribution with a unit mean.

6. Results

This section presents the summary statistics followed by the main findings from the econometric estimations.

6.1. Descriptive Statistics

Tables 2 and 3 present the summary statistics on the main variables, notably the calculated degree of collaboration and competition (Table 2), and the hospitals’ specific characteristics (Table 3). Before interpreting the summary statistics, let us recall that the effective sample size was 60 health centres, including 34 private and 26 public. However, due to the network theory, each private health centre is supposed to be about 26 other public centres. Hence, that would lead to a network of 884, that is 34 times 26 relationships. Thus, the sample size of the study was 60, while the number of observations provided on our output tables was 884. These statistics show that, on average, private health centres share 0.111 patients (collaboration) with public health centres, with a maximum of 11 patients in 2019. We note an increase in this collaboration in 2020 (0.442 on average, with a maximum of 36 patients) and a slight decrease in 2021 (0.365 on average, with a maximum of 27 patients). The low value of the number of patients sent on average is because health centres typically send patients within their administrative geographical health area and have zero patients shared outside. We present in Figures A1–A3 in the Appendix A the aggregate number of patients sent by private health centres to all public health centres in our sample. In particular, the options A, B, and C of these figures outline, respectively, the number of referrals from private to public health centres (A), the number of referrals from private-to-private health centres (B) and the number of referrals from public-to-public health centres (C). These histograms show that more patients are sharing between private health centres than patients sharing from private to public. Figure A4 gives a clear visualisation of the health centre networks where we have 60 nodes (public health centres in red nodes and private health centres in yellow nodes), and the arrow directs the edges from private to public health centres. The size of the edge arrow indicates the degree of collaboration (number of patients sent from private health centre i to public health centre j). Figure A4a–c outline the dynamics of the network of collaboration in 2019, 2020, and 2021, respectively. The increase in the number of patients sent from private health

centres to public health centres in 2020 may be due to increased health services demand during the COVID-19 period.

Table 3. Descriptive statistics.

	Private		Public	
	Mean	St. Dev.	Mean	St. Dev.
Number of experiences years	8.528	7.300	38.636	15.716
Number of specialists	1.806	2.974	1.045	2.984
Number of Generalist	2.028	1.748	0.727	1.518
Number of Sage femme	3.611	2.101	7.591	10.536
Number of Technical lab	1.333	1.195	1.727	3.654
Number of Technical Imag	0.417	0.649	0.636	1.177
Number of bed	10.472	7.378	17.091	24.464
Number of Ambulances	0.114	0.404	0.409	0.734
Nbr. Observation		36		24

Source: Authors, from estimates, 2023.

On the contrary, there is an absence of a significant change over time in the degree of competition (0.823 for 2019; 0.807 for 2020, and 0.822 for 2021). This result indicates that the degree of competition is stable over time, even with the COVID-19 pandemic. However, the degree of competition remains high, as indicated by values greater than 0.80. While this result aligns with the market liberalisation theory, that is, the presence of many suppliers, both public and private, leads to a competitive market, it is contrary to Benin's healthcare pyramid. Indeed, this pyramid does not allow group-based competition (across healthcare zones) but rather co-opetition (intra-healthcare zones).

Furthermore, the health centre's specific characteristics show that on average, the public hospital generally has more years of experience, technical laboratories, technical imaging facilities, ambulances, and a greater number of beds than private health centres (Table 3).

6.2. Main Findings and Discussion

Table 4 presents the results on the effect of competition on collaboration, respectively, in 2019, 2020, and 2021 (columns 2, 3, and 4). Recall that the main objective of this study is to investigate the effect of competition on collaboration in the Benin health system, which is characterised by the coexistence of private and public health centres.

The second column uses as the dependent variable the number of patients sent from private health centres to the public hospital in 2019 (collaboration variable). The third and fourth columns use the collaboration variable for 2020 and 2021. We find that competition has a negative and significant effect on collaboration in 2019 ($-\text{€}4.869$) and in 2021 ($-\text{€}2.875$) and negative, but not significant for 2020 ($\text{€}0.283$). This shows that the level of competition between health centres is harmful to the collaboration between public and private health centres in Benin. Notably, a 10% increase in competition reduces the number of patients the private health sector sends to the public health sector by about 50, 3, and 30 per year, respectively, in 2019, 2020, and 2021. These coefficients appear to be high in absolute value compared to previous findings¹. Indeed, Mascia et al., 2012, estimated coefficients ranging from 0.19 to 0.21 in absolute value in Italy. These discrepancies may be explained by contextual and structural factors. Firstly, our study was conducted with data from a special context, which was a period characterised by the COVID-19 pandemic, while Mascia et al. (2012) work was conducted without any pandemic or crises. Secondly, the regulatory framework of the health system in Benin is likely to differ from that in Italy. Notably, we considered a unidirectional patient flow from private to public health centres, while Mascia et al. assumed a bidirectional flow. Lastly, Mascia et al. (2012) work was based

on a developed country, while ours relied on a developing country. Our findings could be explained by a high degree of niche overlap due to an increasing number of private health centres set up in health zones. Because many private health centres in a health zone reduce the share of patients that each private health centre could receive. Therefore, to limit the decline in its revenue, private health centres will limit sending patients to public health centres, even if the degree of the disease exceeds their competence. Furthermore, the negative effect of the dual health system in Benin could be explained by the importance of expenses facing private health centres. Indeed, these health centres must support all their operating expenses including taxes and equipment costs as well as instalment charges. The government does not provide subsidies to these private health centres. However, another explanation for this result could be that private health centres have more qualified doctors than the public health sector. Our summary statistics presented in Table 2 could strongly support such a statement. Notably, private health centres have an average of more generalist and specialist doctors compared to their peers in the public sector.

Table 4. Effect of competition on collaboration.

	Dependent Variable:		
	Collaboration 2019	Collaboration 2020	Collaboration 2021
Competition	−4.869 *** (1.457)	−0.283 (0.524)	−2.875 *** (0.876)
Number of experiences years	−0.075 ** (0.038)	0.072 (0.045)	0.047 (0.037)
Number of Generalists	−0.188 (0.250)	0.459 *** (0.171)	−0.364 (0.227)
Number of Specialist	−0.150 (0.334)	−0.089 (0.086)	0.262 * (0.147)
Number of Midwife	0.971 ** (0.405)	−0.229 (0.163)	−0.095 (0.171)
Number of Laboratory technician	−0.525 * (0.282)	−0.267 (0.206)	0.354 (0.350)
Number of Imagery technician	−2.596 ** (1.215)	−0.150 (0.212)	−0.355 (0.318)
Number of Bed	−0.228 *** (0.084)	0.066 ** (0.028)	−0.0004 (0.037)
Number of experiences years dyad	0.006 (0.019)	0.002 (0.008)	0.024 (0.016)
Number of Generalist dyad	−0.080 (0.092)	−0.030 * (0.017)	−0.005 (0.027)
Number of Specialist dyad	0.453 * (0.271)	−0.022 (0.051)	0.003 (0.064)
Number of Bed dyad	0.035 (0.035)	−0.014 (0.014)	0.005 (0.027)
Number of Midwife dyad	−0.038 (0.090)	0.029 (0.029)	0.019 (0.073)
Number of Imagery technician dyad	−0.141 (0.139)	0.025 (0.072)	−0.172 (0.122)
Number of Imagery technician dyad	−1.176 *** (0.419)	0.044 (0.118)	0.008 (0.283)
factor (ZoneSani)Allada-Toffo-Z'e	2.542 *** (0.936)	−0.480 (0.387)	1.931 *** (0.654)
factor (ZoneSani)Ouidah-Kpomass'e-Tori-Bossito	−4.402 *** (1.575)	0.901 (0.799)	0.987 (0.720)
Constant	5.810 *** (1.294)	0.344 (0.637)	1.830 ** (0.833)
Observations	884	884	884
Log Likelihood	−128.802	−349.219	−356.325

Note: Source: Authors, from estimates 2023. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Our findings are consistent with some works in the literature which show that competition can harm the collaboration between hospitals (Brekke et al., 2021; Naamati Schneider, 2021; Barros et al., 2016). In particular, the works of Lomi et al. (2014) support this result by showing that the high increase in niche overlap gradually leads to the dominance of the strength of competitive constraints by causing the reduction in the propensity of hospital organisations to collaborate. But this result is contrary to other empirical works that show the simultaneous coexistence of competition and collaboration between public and private hospitals (De Pourcq et al., 2019; Mascia et al., 2012; Halverson et al., 2000). This result between public and private health centres in Benin suggests that the state regulates the establishment of private hospitals in health zones to ensure their survival, as in the opening of pharmacies that respect given distances between them.

In contrast to the results for 2019 and 2021, the effect of competition on collaboration between public and private health centres remains statistically insignificant in 2020. This result could be explained by the appearance of COVID-19 towards the end of 2019 in Benin, which compelled the entire health system to work together to face the challenge of the health crisis. So, during COVID-19, having more patients may reduce competition between public and private health centres. Also, during this period, the government adopted several measures to strengthen the synergy of action of the entire health system. It established a zero-interest financing scheme for businesses, including private health centres, to facilitate their access to credit. Funds were mobilised for the purchase of biomedical equipment, protective gear, testing supplies, and oxygen, also benefiting private facilities. Additionally, the government incorporated the private sector into health governance mechanisms through coordination committees and the support of the Health Sector Regulatory Authority, ensuring a coherent and collaborative response to the crisis. This would have made it possible to further pool the differences in resources between public and private health centres and above all by considering the differentials in the volume of activity which makes it possible to reduce the level of competition. The rationale for the 2020 results agrees with the work of Mascia et al. (2012) and Mascia and Di Vincenzo (2011) which shows that the negative effect of competition decreases if hospitals were more likely to create cooperative network links. This situation invites the state to adopt measures favouring cooperation links between health centres.

In addition, we note that having a greater number of years of experience, number of laboratory and imagery technicians, and number of beds leads to a decrease in collaboration between private and public health centres. The reason that can justify this result is that with more experience, there would be more notoriety of private health centres with these characteristics, making them more self-sufficient in providing healthcare effectively. On the other hand, we note that only the greater gap between private and public health centres in terms of the number of technical laboratories reduces the collaboration between them. Our results are robust to alternative specifications. Notably, we re-estimated our model by including interaction terms between competition and medical equipment on the one hand, and a Tobit type I model on the other hand. First, our results confirmed that the greater power of monopoly reduces the level of collaboration between public and private health centres (Tables A1 and A2 in the Appendix A). Second, COVID-19 reduces the detrimental effects of competition on the level of collaboration (Tables A1 and A2 in the Appendix A). Third, we found that medical equipment significantly increases the power of monopoly of private health centres, leading to a reduction in the level of collaboration between public and private healthcare providers. Finally, the estimates from the Tobit type I model (Tables A1 and A2 in the Appendix A) are robust to the negative binomial specification.

In sum, our results indicate that COVID-19 mitigated the detrimental effect of competition on the health system in Benin. These findings suggest that, although the coexistence

of public and private health centres can hinder collaboration, the dual health system tends to self-regulate in favour of greater collaboration during crises such as the recent COVID-19 pandemic. Thus, while the dualism of the health system in Benin may undermine the population's well-being, particularly in times of crisis, it can also foster cooperative dynamics in response to external shocks. However, our findings also reveal that the benefits of co-competition are not sustained over time, highlighting the lack of durability in government measures implemented during the pandemic, especially financial support to the private sector and more inclusive governance structures.

We acknowledge that this study has certain limitations. First, the findings cannot be generalised to the entire country, as the data were collected solely in one administrative area, the Atlantic Department of Benin, which may not be representative of all departments. Second, the exclusive reliance on quantitative and non-centralised administrative data limits the depth of understanding regarding the mechanisms through which collaboration between the two sectors enhances patient welfare.

Building on the limitations identified, future research could pursue several directions to strengthen the robustness and applicability of findings. First, to address potential inconsistencies arising from the use of non-centralised administrative data, collaboration with national health authorities is recommended. This would enable access to more standardised and comprehensive datasets, improving data quality and comparability across regions. Second, the absence of a qualitative component limits the contextual depth of the analysis. Furthermore, the assumption of a unidirectional patient referral flow may oversimplify the complexity of actual referral systems. Future studies should consider modelling bi-directional flows or empirically validating referral patterns through stakeholder interviews or health system mapping. Incorporating qualitative methods, such as interviews or focus groups, with healthcare professionals, administrators, and patients could yield richer insights into the dynamics of intersectoral collaboration and patient welfare. Taken together, these avenues would offer a more holistic understanding of the mechanisms and contextual factors shaping healthcare delivery outcomes.

7. Conclusions

Ensuring adequate and affordable health services for all is one of the 17 Sustainable Development Goals of the United Nations. This goal poses a challenge for developing countries like Benin, characterised by high rates of people lacking access to healthcare services. The adequacy of resources for public health infrastructure remains problematic due to fiscal implications, while the path of public–private partnerships could offer prospects. This study analysed the extent to which the coexistence of public and private health centres does not detrimentally affect collaboration in the health system. Specifically, we focused on the effect of COVID-19 on the dynamic of competition and collaboration. Using administrative data, we employed descriptive, network, and econometric analyses to estimate the impact of competition on collaboration between public and private health centres. The conclusions drawn from the results are twofold. Competition within the health system in Benin adversely affected collaboration between public and private health centres before the COVID-19 pandemic. However, we demonstrated that the detrimental effect of the dual health system, i.e., competition on collaboration between health centres, was statistically insignificant. Our findings hold policy recommendations and implications for African countries grappling with budgetary constraints to ensure adequate healthcare services. First, governments need to establish a sustainable health financing mechanism for the private sector by creating a dedicated financing framework, such as a health investment fund or guarantee facility, to support private health centres with accessible, low-interest loans or grants. This would reduce their financial vulnerability and strengthen their abil-

ity to contribute to national health goals, especially in emergencies. Second, promote the institutionalisation of financial resilience measures. Governments may move beyond temporary, crisis-driven financial interventions by integrating private sector support into national health financing strategies. This could include tax relief, subsidies for essential services, or public–private performance contracts tied to service delivery and equity outcomes. Third, strengthen inclusive health governance structures by formally including private health sector representatives and civil society in decision-making bodies at both national and decentralised levels. This promotes shared accountability, transparency, and coherence in health system planning and implementation. Lastly, link financial support to governance participation and accountability by conditioning financial support to private health actors on their engagement in joint governance processes and adherence to national health standards. This ensures that public investment in private actors translates into public value and improved system-wide performance.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author due to (Only the National Council of Statistics is allowed to publish health data).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Robustness tests

Table A1. Tobit type I estimates with Laboratory equipment as interaction terms.

	Dependent Variable:		
	Collaboration 2019	Collaboration 2020	Collaboration 2021
Competition	−5.599 (6.542)	−10.693 *** (4.055)	−6.842 * (3.753)
Competition×Laboratory	0.390 (3.491)	0.046 (2.246)	−1.235 (1.970)
Years of experience	0.220 (0.234)	0.141 (0.185)	−0.003 (0.140)
Number of Generalist	1.768 (1.314)	3.171 *** (0.928)	0.932 (0.713)
Number of Specialist	−1.336 (1.076)	0.597 * (0.361)	−0.034 (0.395)
Number of Midwife	2.304 * (1.199)	0.933 (0.715)	0.802 (0.591)
Number of Laboratory technicians	0.177 (2.846)	−2.585 (2.151)	−0.006 (1.740)
Number of Imagery technicians	−5.912 * (3.502)	−3.105 ** (1.428)	−2.515 * (1.408)

Table A1. *Cont.*

	Dependent Variable:		
	Collaboration 2019	Collaboration 2020	Collaboration 2021
Number of Beds	−0.674 ** (0.311)	0.056 (0.172)	0.259 * (0.148)
Years of Experience dyad	−0.004 (0.071)	−0.043 (0.061)	−0.103 * (0.053)
Number of Generalist dyad	−0.228 (0.361)	−0.234 ** (0.102)	−0.154 (0.104)
Number of Specialists dyad	0.628 (0.966)	−0.374 (0.319)	−0.084 (0.329)
Bed dyad	0.095 (0.156)	0.039 (0.099)	−0.054 (0.093)
Sage dyad	−0.375 (0.442)	0.440 * (0.241)	0.502 ** (0.230)
Laboratory dyad	−0.278 (0.790)	−1.045 * (0.592)	−1.126 ** (0.530)
Imagery dyad	0.550 (1.807)	−0.688 (1.066)	−1.733 (1.066)
factor(ZoneSani)Allada-Toffo-Z'e	8.905 ** (3.510)	8.236 *** (2.421)	5.404 ** (2.114)
factor(ZoneSani)Ouidah-Kpomass'e-Tori-Bossito	−1.401 (4.809)	10.340 *** (3.020)	7.778 *** (2.283)
logSigma	2.288 *** (0.189)	2.374 *** (0.105)	2.214 *** (0.104)
Constant	−20.660 *** (7.650)	−17.228 *** (4.927)	−10.673 *** (3.802)
Observations	884	884	884
Log Likelihood	−147.263	−360.847	−363.677
Akaike Inf. Crit.	334.526	761.694	767.354

Note: Any statistically significant estimates are denoted with asterisks. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A2. Tobit type I estimates with Imagery equipment as interaction terms.

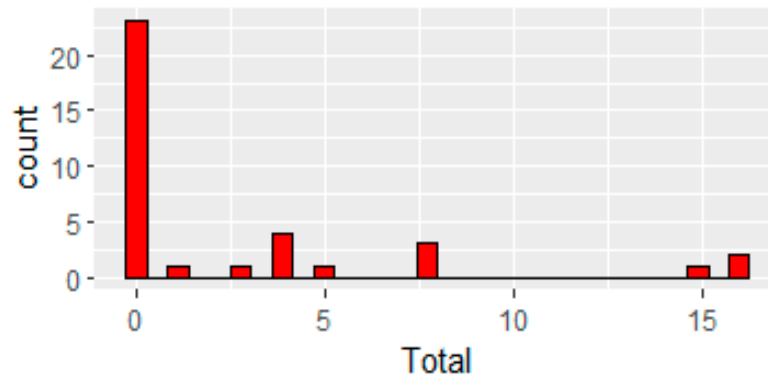
	Dependent Variable:		
	Collaboration 2019	Collaboration 2020	Collaboration 2021
Competition	−5.671 (6.057)	−10.064 *** (3.862)	−6.756 * (3.551)
Competition × Imagery	1.866 (10.584)	−2.117 (4.928)	−4.571 (4.941)
Years of Experience	0.223 (0.232)	0.133 (0.183)	−0.004 (0.139)
Number of Generalist	1.773 (1.307)	3.177 *** (0.930)	0.905 (0.717)
Number of Specialist	−1.330 (1.074)	0.586 (0.363)	−0.078 (0.399)
Number of Midwife	2.329 * (1.217)	0.900 (0.712)	0.800 (0.583)
Number of Laboratory technicians	0.432 (1.537)	−2.537 ** (1.285)	−0.816 (1.026)
Number of Imagery technicians	−7.326 (8.932)	−1.468 (4.039)	0.869 (3.838)
Number on Beds	−0.677 ** (0.310)	0.061 (0.171)	0.253 * (0.148)
Experience dyad	−0.003 (0.071)	−0.043 (0.061)	−0.102 * (0.053)
Number of Generalist dyad	−0.227 (0.360)	−0.234 ** (0.102)	−0.152 (0.105)
Number of Specialist dyad	0.630 (0.965)	−0.381 (0.319)	−0.083 (0.328)
Bed dyad	0.094 (0.156)	0.042 (0.099)	−0.054 (0.093)
Sage dyad	−0.374 (0.441)	0.438 * (0.241)	0.497 ** (0.231)
Laboratory dyad	−0.280 (0.790)	−1.043 * (0.593)	−1.133 ** (0.530)

Table A2. Cont.

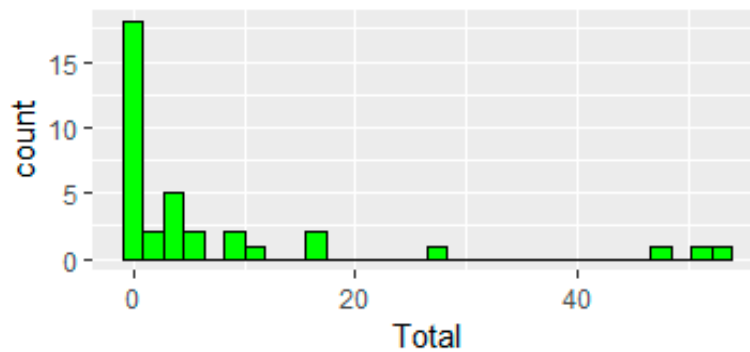
	Dependent Variable:		
	Collaboration 2019	Collaboration 2020	Collaboration 2021
Imagery dyad	0.542 (1.806)	-0.706 (1.068)	-1.687 (1.069)
factor(ZoneSani)Allada-Toffo-Z'e	8.892 ** (3.505)	8.251 *** (2.423)	5.480 *** (2.118)
factor(ZoneSani)Ouidah-Kpomass'e-Tori-Bossito	-1.464 (4.806)	10.325 *** (3.011)	7.850 *** (2.276)
logSigma	2.287 *** (0.189)	2.375 *** (0.105)	2.212 *** (0.104)
Constant	-20.641 *** (7.462)	-17.595 *** (4.942)	-10.692 *** (3.760)
Observations	884	884	884
Log Likelihood	-147.254	-360.755	-363.443
Akaike Inf. Crit.	334.507	761.509	766.887
Bayesian Inf. Crit.	429.739	856.741	862.118

Note: Any statistically significant estimates are denoted with asterisks. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

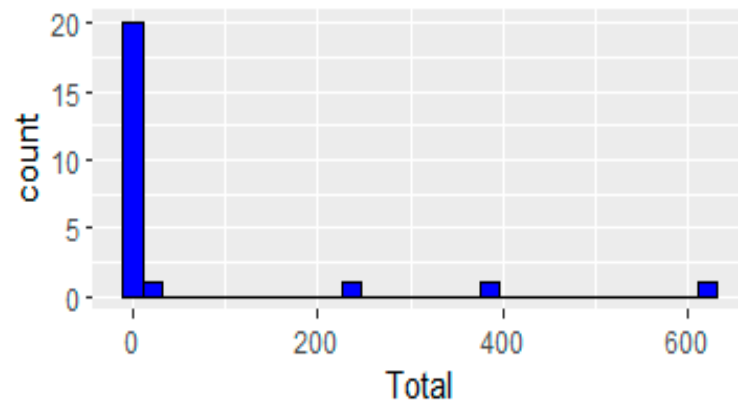
A. Number of referrals from private to public health centres



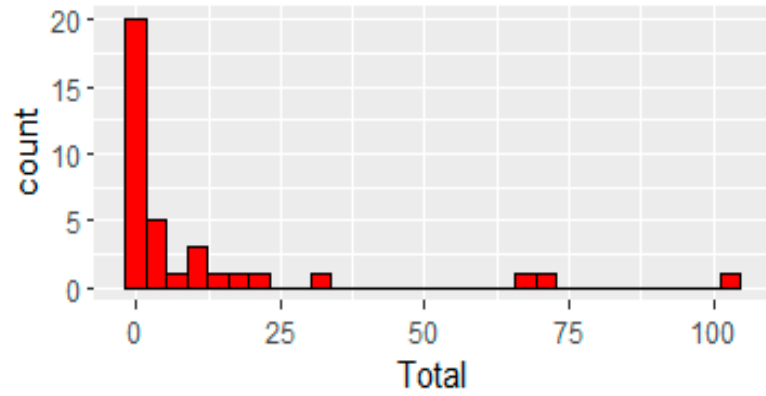
B. Number of referrals from private-to-private health centres



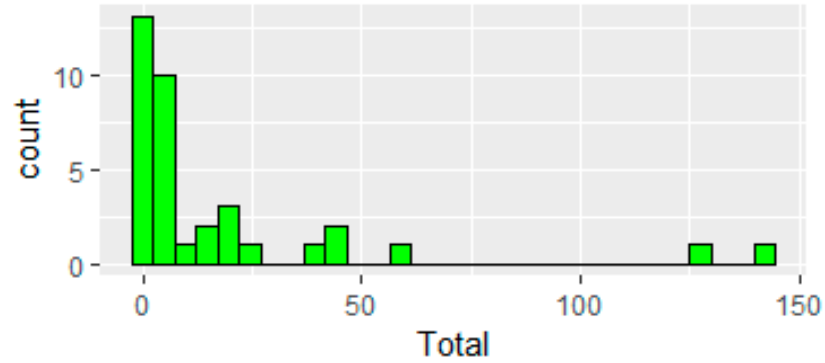
C. Number of referrals from public-to-public health centres



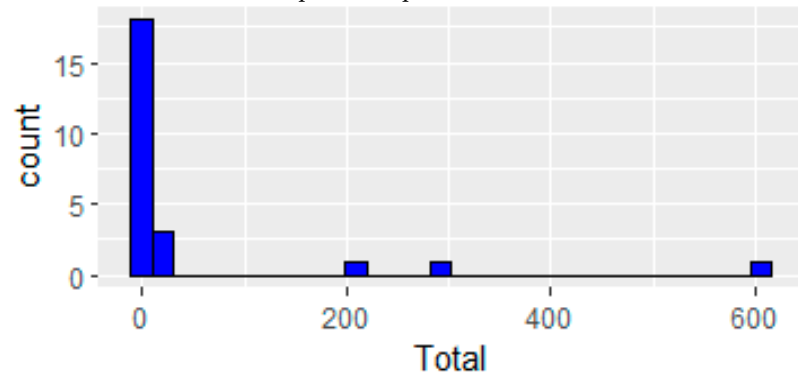
A. Number of referrals from private-to-public -health centres



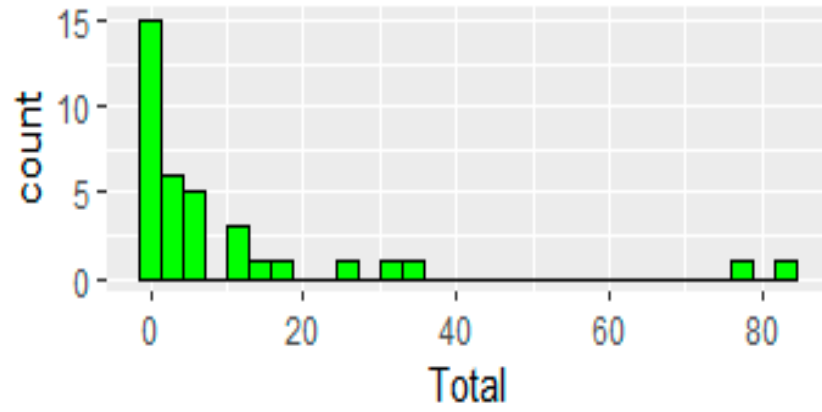
B. Number of referrals from private-to-private health centres



C. Number of referrals from public-to-public health centres



B. Number of referrals from private-to-private health centres



C. Number of referrals from public-to-public health centres

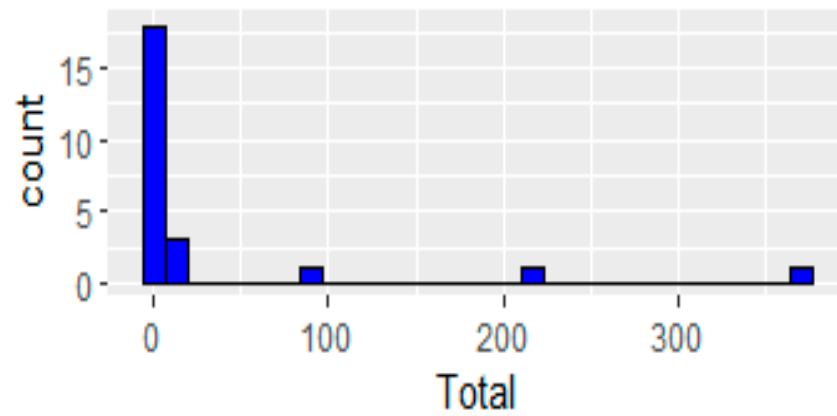


Figure A3. Degree of collaboration in 2021.

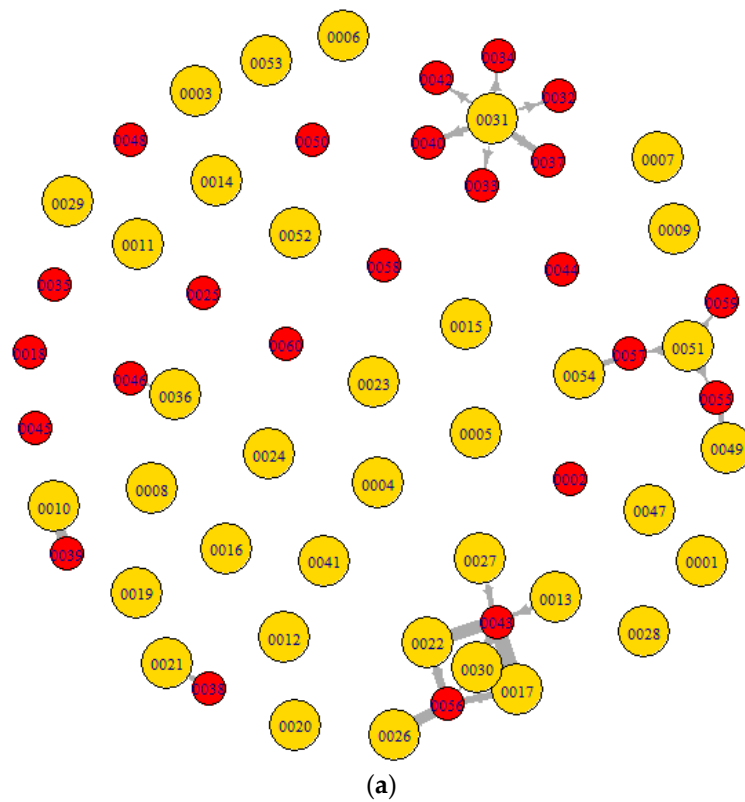


Figure A4. Cont.

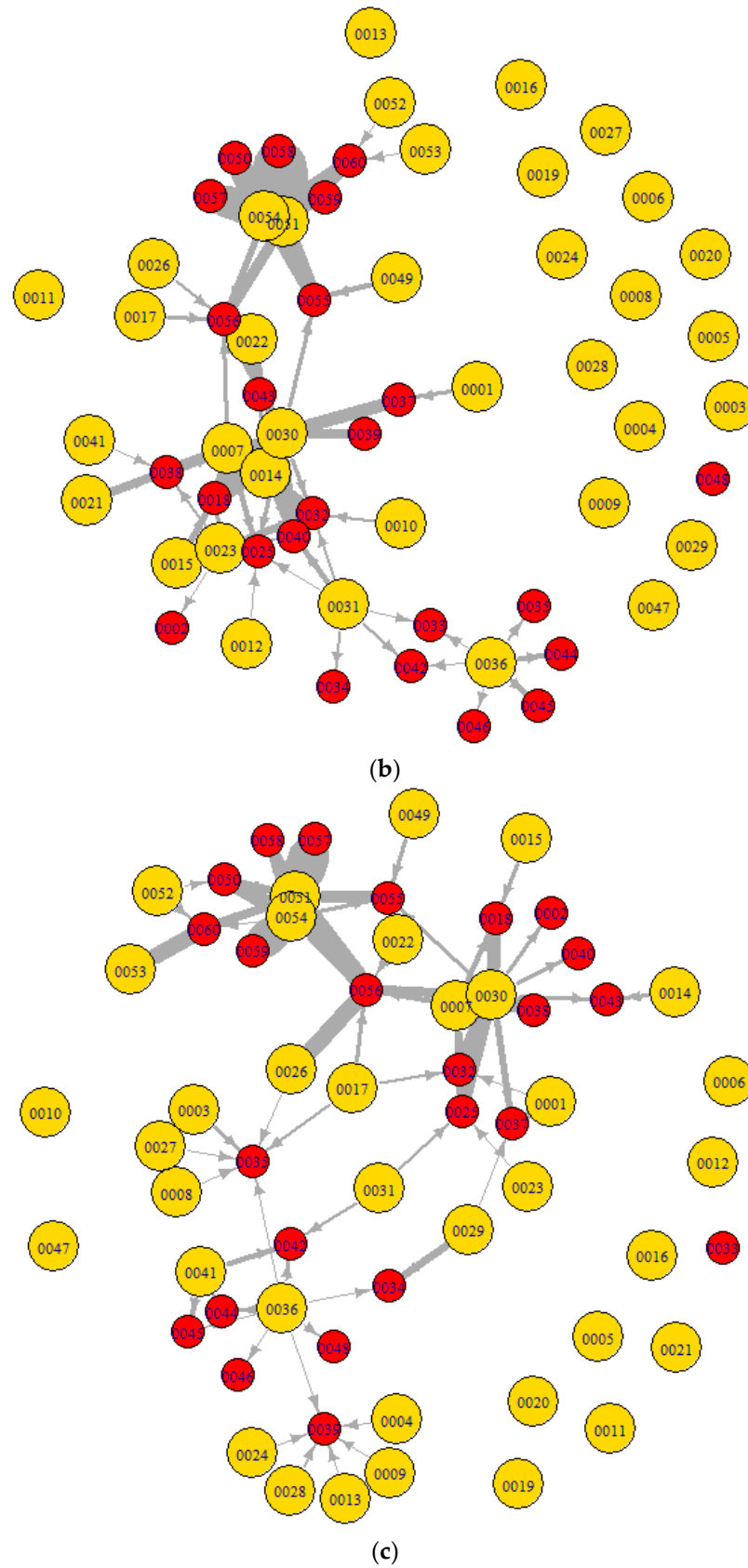


Figure A4. Network of health centres. (a) 1: Network of Collaboration in 2019. (b) 2: Network of Collaboration in 2020. (c) 3: Network of Collaboration in 2021.

Note

¹ Though our model and that of Mascia et al. (2012) were not estimated in log form, our comparison is still valid. This is because the mean of the collaboration variable in our study ranged between 0.11 and 0.44, which is lower than Mascia et al. (2012)'s mean that ranged between 0.72 and 0.73. It is important to note that zero-inflated Poisson regression estimation is not consistent when logging the dependent variable for two reasons. First, the dependent variable is a count variable, not a continuous variable. Second, the dependent variable contains excess zeros.

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