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Contents

Articles

Review

Brief Report

Short Report

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Article

Public and private healthcare administration priorities in new electronic age

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Abstract: The work defines the such priorities of healthcare administration as creation of free-tax medical town-campuses and reduction of costs for accessibility of medical services, increase in service speed and improvement in the quality, constant process of improving the qualification, wide-regional network management, combination of public and private insurance, essential increase in healthcare costs of GDP, striving for the highest standards of technical level, ensuring the non-profitability of medical organizations, combining various stages of medical services, electronic transparency and direct communication of financial reporting with some needful maintaining of commercial secrets and bank accounts, usage of wide outsourcing practices.

Keywords: healthcare management; economic priorities; new electronic age

1. Introduction

Some prophet-experts foresaw [1] the electronic age, the period from the 30s to the 80s of the last century. But this was only the introduction to the real era of electronic business, including lightning-fast medical services with vital information flows, the rapid need for which was shown and truly started by the COVID-19 pandemic (20s of the 21st century) with completely new methodological approaches.

To study lightning-fast managerial decisions, I used methods of a neuro-economic nature, optimal mathematical grouping, and even analogies of physical laws.

I am especially grateful to the very talented Harvard scientists, led by Michael Porter [2,3], who pay great attention to the study of health care management problems and competition and, piece by piece, collect the fewest scientific achievements around the world.

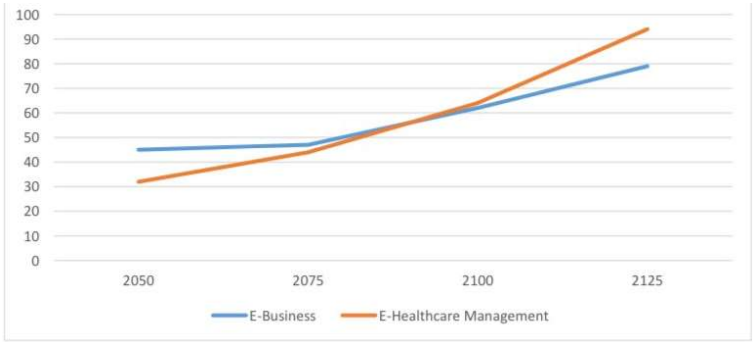

Figure 1. E-business and E-healthcare management in 2050–2125.
Source: Author's estimates of the world medicine 5490 cases (from medicine birth time by legend about Georgian Medea to modern 2023).

According to our calculations, which were founded on world medicine cases from medicine birth time by legend about Georgian Colchis Medea [4,5] to

nowadays, by the middle of the 21st century, electronic business will reach almost half of all business turnover and vital medicine will grow especially rapidly in it (**Figure 1**). By the end of this century, the level of e-business and e-medicine will be approximately equal, and long-term strategic calculations based on predictive extrapolation of the 3-century past showed that the jump in favor of online relationships will even exceed the 90% mark.

2. Ways to solve the problem of access of qualitative medicine

At the Georgian University, Geomedi, we began teaching a course on managerial costs in medicine 10 years ago and at the same time conducted multiple studies that led to the results that inflated management costs can be reduced by almost half, and it is necessary to think about more speed in the provision of emergency care.

According to objective forecasts, the costs per patient (**Figure 2**) and the same proportion of time spent per patient (**Figure 3**) are significantly reduced, and in e-healthcare management, after a century, they will reach approximately 19% and 11% levels, respectively, from the middle of the modern century, but if we allow, as researched by me [6,7], hidden monopolies to operate freely in the economy and interfere with objective competition, this will not happen.

Figure 2. Costs per patient by healthcare management and E-healthcare management in 2050–2125.

Figure 3. Time spent per patient by healthcare management and E-healthcare management in 2050–2125.

Source for both figures: Author's estimates of the world medicine 3510 cases (1509–2023).

Our observations have shown that in medicine, in no case should one allow the desire for monopoly profit and look at the patient as a source of profit. In addition to this, we must strive to reduce the tax burden on medical institutions as much as possible and help them as much as possible from the tax revenues accumulated from the population by free economic zones [8].

In my opinion, it would be great to create international medical tax-free zonal spaces (along state borders and with invitations from prominent specialists from both countries here), which would significantly reduce the movement of patients and the managerial costs [2,3] and losses of time and money. International medical zones, according to our assumptions, will also significantly stabilize demographic imbalances, and we will deliberately and jointly make people's lives happier. We are going to calculate the happiness index and the correlation of costs and projected income and invite scientists to do joint research.

3. Conclusion

After long research observations, I have determined the priorities of the most competitive and optimally effective intertwined public and private healthcare administration:

1) Creation of free medical town-campuses with a wide range of tax incentives and maximum reduction of indirect and fixed costs for better accessibility of medical services, in addition to constant monitoring of implicit costs;
2) Maximizing the speed of service: the creation of the above-mentioned international medical zones will make services much more comfortable in our difficult time of growing migration flows;
3) Maximum improvement in the quality of medicine with a constant connection to science;
4) Organization of a constant process of improving the qualifications of doctors and nurses and increasing their wages;
5) Expansion of wide-regional network management by the delegation of financial and transport services to the capital and regional centers;
6) Combination of public and private insurance with a Swiss proportion of 1:3;
7) General increase in healthcare costs to the same proportion of 1:3 of GDP;
8) Striving for the highest standards of technical level in medical and preventive institutions;
9) Ensuring the non-profitability of medical organizations by distributing profits for the purpose of improving the scientific potential of primary and subsequent medicine;
10) Combining various stages of medical services with the condition of reintroducing competition to the medical service in the event of the manifestation of monopoly sentiments;
11) Electronic transparency and direct communication of financial reporting should not mean a misunderstanding of maintaining trade secrets and the need to have bank accounts when there is a need to aggravate risks;
12) Usage wide outsourcing practices when it is necessary to attract doctors with the required qualifications.

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Article

Better birth outcomes: The investment that saves lives

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Abstract: This study utilizes CDC data to analyze birth outcomes for at-risk mothers involved in the Pathways HUB Community Action (PHCA) in Summit County, Ohio. The purpose is to understand the cost savings of providing interventions that will result in positive birth outcomes. The data, compared to the Ohio Public Health Data Warehouse and March of Dimes statistics, shows similar rates of singleton births. The study adjusts for inflation using the Producer Price Index from the St. Louis Federal Reserve. Results indicate that reducing prematurity rates among HUB clients could lead to significant cost savings, totaling approximately $1.2 million between 2017 and 2022, with the greatest cost savings for Black at-risk mothers and infants. This manuscript aims to achieve two objectives: first, to highlight the benefits of addressing health disparities affecting at-risk pregnant women; and second, to demonstrate the methodology for calculating cost savings using available birth outcome data.

Keywords: premature births; at-risk mothers; pathways HUB community action

Infant mortality continues to be a major concern in Ohio, especially among Black mothers. Ohio's infant mortality rates have shown complex trends since 2016. While post-2016 data is limited, earlier studies (2008–2015) identified significant geographic clustering of infant mortality in urban areas [1]. Education also plays a role in birth outcomes, as higher high school graduation rates are associated with lower teen birth rates and better infant health outcomes [2] except for some studies among Black women. The COVID-19 pandemic initially increased the risk of preterm births—a major factor in infant mortality.

However, by 2022, this effect had diminished, particularly in areas with early vaccine distribution [3]. Historical data (2003–2005) also indicates that infant mortality risk increases progressively with births between 32 and 38 weeks of gestation, with different causes and timings of death depending on gestational age [4]. These findings underscore the complexity of factors influencing infant mortality in Ohio.

Research shows that minority groups, particularly Black individuals, have been disproportionately impacted by both COVID-19 and non-COVID-19 related mortality since 2016, both in Ohio and across the United States. Historically, Black infants in major Ohio cities have faced significantly higher mortality risks compared to white infants, even when controlling for various maternal and infant characteristics [5]. The COVID-19 pandemic has further exacerbated these disparities, with minority populations experiencing higher rates of infection, hospitalization, and death compared to white populations across many states [6]. In particular, Black non-Hispanic males have faced a disproportionate share of both COVID-19 and non-COVID-19 related

excess mortality [7]. Contributing factors include social vulnerability, healthcare disparities, and reduced access to medical services during the pandemic. Additionally, education levels have been linked to teen birth rates and adverse birth outcomes, including infant mortality, in Ohio [2].

Ohio [2] has implemented several targeted programs to address the high rates of infant mortality among minority populations, particularly Black infants. One of the key initiatives is the Ohio Infant Mortality Reduction Initiative (OIMRI), which focuses on providing support to high-risk pregnant women through community health worker-led home visits. This program specifically targets Black mothers, who are disproportionately affected by infant mortality. The community health workers offer education on prenatal care, help connect women to healthcare services, and provide support throughout pregnancy and early motherhood. Research indicates that early enrollment in OIMRI is associated with increased prenatal care visits, which can potentially reduce the risks associated with infant mortality [8,9] but the overall benefit is unknown.

In addition to OIMRI, Ohio has invested in expanding access to Medicaid and improving healthcare coverage for pregnant women through the postpartum period until an infant turns 1 year old. Programs like Moms and Babies First and Pathways Community HUB model focus on addressing social determinants of health, such as housing and transportation, which are critical for improving birth outcomes among minorities. These programs work to ensure that women receive comprehensive care, including regular check-ups, mental health services, and substance abuse counseling if needed [1,10]. These programs provide Ohio's at-risk mothers with support to navigate their life needs and pregnancy for the best possible birth outcome.

Infant mortality and preterm births impose significant economic burdens on healthcare systems and society. The cost of preterm births alone in the United States is estimated to be around $26.2 billion annually, with an average of $65,000 per preterm infant. These costs include initial hospitalization, long-term medical care, and lost productivity due to disabilities often associated with premature births [11]. Infant mortality further amplifies these costs, as it involves not only the direct medical expenses but also the broader societal impact. For example, the Centers for Disease Control and Prevention (CDC) estimated that the cost of infant mortality in 2001 was around $10.2 billion, a figure that has likely increased in recent years due to inflation and rising healthcare costs. This estimate encompasses direct healthcare costs, loss of future productivity, and the emotional and psychological toll on families and communities [12].

Preterm birth-related expenses are particularly high because premature infants often require extensive care, including prolonged stays in neonatal intensive care units (NICUs), specialized medical equipment, and follow-up care for developmental delays or chronic conditions. These costs are compounded by the fact that preterm infants are at a higher risk for lifelong health problems, such as respiratory issues, neurological disabilities, and learning disorders, which require ongoing medical and educational interventions [13].

Addressing infant mortality and preterm births through preventive measures and improved maternal healthcare can potentially reduce these substantial costs. Programs aimed at reducing these adverse birth outcomes, such as enhancing prenatal care access

and addressing social determinants of health, are not only crucial for improving public health but also for alleviating the economic burden on society.

The current investigation examines the cost savings associated with a Pathway HUB located in Summit County, Northeast Ohio. Established in 2016, this HUB has provided services to over 1000 at-risk women [14]. The primary objective of this research is to assess the financial impact by comparing preterm birth rates among mothers participating in the HUB's programming with the overall preterm birth rates in the county.

1. Methods

This inquiry uses data sourced from the Centers for Disease Control and Prevention (CDC), which provides comprehensive birth statistics categorized by race, prematurity status, and singleton versus multiple births. This data is compared to the birth outcomes for at-risk mothers participating in the Pathways HUB Community Action, located in Summit County, Ohio. Summary data from the March of Dimes (MOD) indicate that approximately 97% of births in Summit County during the study period are singletons. A comparison of the CDC data with aggregated OPHDW data reveals a similar percentage of singleton births as reported by the MOD.

For inflation adjustments, the Producer Price Index by Commodity: Health Care Services (PPI) from the St. Louis Federal Reserve Bank is employed. Twelve monthly PPI values are averaged for each year to estimate the annual PPI. In contrast to a previous study, where only January PPI values were used—leading to slightly higher year-over-year inflation—this approach provides a more accurate reflection of inflation trends.

The MOD Cost of Prematurity research utilizes 2016 health care costs. To adjust these costs to reflect the study period, cost increases since 2016 are calculated and applied to the MOD's differential cost of prematurity for Ohio in 2016. These values are provided in **Table 1**.

Table 1. MOD cost of prematurity with inflation adjustments.

Year	Average health care PPI	PPI inflation vs. 2016	Inflated cost of prematurity
2016	114.442		$62,389
2017	116.175	1.51%	$63,334
2018	118.625	3.66%	$64,669
2019	121.158	5.87%	$66,050
2020	124.425	8.72%	$67,831
2021	128.167	11.99%	$69,871
2022	131.785	15.15%	$71,844

The process to determine prematurity cost savings is as follows:

1) Find the prematurity rate among HUB clients by dividing the number of premature births by the total number of births for the year.
2) Find the prematurity rate in the county, exclusive of HUB clients. To do this, subtract the number of HUB births from the CDC's number of births in the county to obtain the total number of non-HUB births. Subtract the number of premature

HUB births from the CDC's premature births in the county. Divide the non-HUB premature birth count from the total number of non-HUB births.

3) Multiply the expected prematurity rate by the total number of HUB births to obtain the expected number of premature births in the HUB.
4) Subtract the actual number of premature births in the HUB from the expected premature births in the HUB based on the non-HUB prematurity rate.
5) Multiply the expected reduction in premature births by the cost of prematurity for the year.

A hypothetical calculation for 2017 was computed accordingly:

1) HUB prematurity rate = HUB premature births / HUB All births = 10/100 = 10%
2) Non-HUB premature births = CDC premature births − HUB premature births = 610 − 10 = 600
3) Non-HUB all births = CDC all births − HUB all births = 5100 − 100 = 5000
4) Non-HUB prematurity rate = Non-HUB premature births/Non-HUB all births = 600/5000 = 12%.

The outcomes for the hypothetical 2017 example are provided in **Table 2**.

Table 2. Outcomes for 2017 Computations.

	HUB		**CDC**		**Non-HUB**		
Premature births	All births	Prematurity rate	Premature births	All births	Premature births	All births	Prematurity rate
10	100	10%	610	5100	600	5000	12%

Likewise, the expected premature births in the HUB were computed using the Non-HUB prematurity rate multiplied by HUB all births = 12% × 100 = 12.

The reduction in premature birth was computed using the Expected premature births − HUB premature births = 12 − 10 = 2.

The calculated cost savings based on this computation is 2 × $63334 = $126,668 for 2017.

2. Results

Table 3 provides the computation for each year from 2017 through 2022.

Table 3. Expected cost savings due to reduced prematurity by year.

Year	**Expected premature births**	**Actual premature births**	**Difference**	**Cost savings per birth**	**Cost savings for year**
2017	2.02	1	1.02	$63,334	$64,290
2018	12.02	11	1.02	$64,669	$65,973
2019	7.97	9	-1.03	$66,050	($67,907)
2020	16.50	8	8.50	$67,831	$576,559
2021	17.97	13	4.97	$69,871	$347,086
2022	25.98	23	2.98	$71,844	$213,901
Totals	82.45	65	17.45		$1,199,900

Results indicate an overall savings of approximately $1.2 million. Expanding on previously publish research, the expected cost savings were computed by reported race of the mothers. This was accomplished based on the computations provided in

Appendix. Results are presented in **Table 4**.

Table 4. Expected savings by reported race.

Year	Black	White	Other	Total
2017	$40,061	$24,229	$ → -	$64,290
2018	($65,262)	$121,116	$10,119	$65,973
2019	($141,551)	($12,475)	$86,118	($67,907)
2020	$505,484	$174,526	($103,452)	$576,559
2021	$264,665	$81,618	$803	$347,086
2022	$111,282	$89,901	$12,718	$213,901
	$714,679	$478,915	$6306	$1,199,902

Note: Insufficient data available for "Other" in 2017. Parentheses indicated negative balance.

As indicated above, the greatest savings is realized for the Black at-risk mothers participating in the supports provided by the PHCA.

3. Discussion

The greatest savings are realized among Black at-risk mothers, as detailed in the race-specific analysis. Cost savings are highest for Black mothers participating in pregnancy interventions due to the disproportionately high rates of preterm births and associated health complications within this demographic. Black women in the US face significant health disparities, particularly in maternal care, due to structural racism, socioeconomic stressors, and limited access to quality healthcare. They experience higher rates of maternal mortality and morbidity compared to white women [15,16].

These disparities are rooted in historical legacies of racism and sexism, leading to overrepresentation in low-wage, hazardous healthcare jobs [17]. Black women encounter racial discrimination in healthcare settings, including dismissal of pain concerns and unfair treatment based on insurance [18]. Structural barriers, implicit biases, and medical mistrust contribute to reduced participation in health services [19,20]. Addressing these disparities requires comprehensive approaches targeting structural barriers, bias, and socioeconomic factors [21]. These factors contribute to higher healthcare costs related to managing preterm births and their complications.

Interventions like the Pathways HUB Community Action (PHCA) program specifically target these at-risk populations, offering enhanced prenatal care, education, and support that can reduce the incidence of preterm births. In addition, families are partnered with a certified Community Health Worker who is an expert in navigating these complex systems, often learned through their lived experiences. CHWs, often live in the neighborhoods where they work, speaking the common language of the community and understanding the cultural norms in that community. By lowering the preterm birth rate among Black mothers, these programs not only improve health outcomes but also lead to substantial cost savings. The findings of the current investigation underscore the critical importance of culturally competent, targeted interventions in reducing health disparities and associated costs.

Research on the impact of the Pathway HUBs in Ohio needs to continue. Specifically, research on how stress contributes to preterm delivery among minority

women is essential for mitigating these disparities. Also, once the data is available, outcomes beyond the COVID-19 years will likely provide greater cost savings.

4. Conclusion

The HUB creates a network of agencies within communities who replicate an evidenced based model, share data in a unique data system for documentation and tracking, prevent duplication of services, and provide a standard of care which addresses system inequities.

CHWs are the foundation of a PCH. CHWs assess family needs, connect them to resources and services, and provide insight about systemic barriers. Through the documentation of these risk factors, both successfully and unsuccessfully being mitigated, community level data is compiled, providing quantifiable data to create policy and system change. The power of this work allows for communities to work downstream at the individual level to address the factors impacting infant mortality and consequences of preterm/ premature births while working upstream to transform these systems. The cost-savings demonstrated in this analysis provides opportunities for discussions in communities about re- distribution of funds towards upstream efforts or primary prevention such as the PCH.

The model is able to be right sized for individual communities, addressing the health-related social needs in communities beyond infant mortality and preterm births. While much of the Hub work in Ohio began with infant and maternal health, some of the greatest opportunities for cost savings may be in the areas of chronic conditions such as diabetes, hypertension and asthma. Future research could apply the same principles in this study to assess the ROI for individuals with chronic conditions as well as evaluate their most common health related social needs and risk factors in Ohio.

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Appendix

Table A1. Expected cost savings due to reduced prematurity: Black infants.

	Expected premature births	Actual premature births	Difference	Cost savings per birth	Cost savings for year
2017	1.63	1	0.63	$63,334	$40,061
2018	8.99	10	−1.01	$64,669	($65,263)
2019	5.86	8	−2.14	$66,050	($141,551)
2020	12.45	5	7.45	$67,831	$505,487
2021	11.79	8	3.79	$69,871	$264,666
2022	18.55	17	1.55	$71,844	$111,282
All years	59.27	49	10.27		$714,682

Table A2. Expected cost savings due to reduced prematurity: White infants.

	Expected premature births	Actual premature births	Difference	Cost savings per birth	Cost savings for year
2017	0.38	0	0.38	$63,334	$24,229
2018	1.87	0	1.87	$64,669	$121,116
2019	0.81	1	-0.19	$66,050	($12,475)
2020	2.57	0	2.57	$67,831	$174,527
2021	4.17	3	1.17	$69,871	$81,618
2022	4.25	3	1.25	$71,844	$89,900
All years	14.06	7	7.06		$478,915

Table A3. Expected cost savings due to reduced prematurity: Other infants.

	Expected premature births	Actual premature births	Difference	Cost savings per birth	Cost savings for year
2017	0	0	0	$63,334	$0
2018	1.16	1	0.16	$64,669	$10,119
2019	1.30	0	1.30	$66,050	$86,119
2020	1.47	3	-1.53	$67,831	($103,452)
2021	2.01	2	0.01	$69,871	$803
2022	3.18	3	0.18	$71,844	$12,718
All years	9.12	9	0.12		$6,307

Table A4. Expected cost savings due to reduced prematurity: 2017.

Race	Expected premature births	Actual premature births	Difference	Cost savings per birth	Savings
Black	1.63	1	0.63	$63,334	$40,061
White	0.38	0	0.38	$63,334	$24,229
Other	0	0	0	$63,334	$ 0
Total	2.02	1	1.02		$64,290

Table A5. Expected cost savings due to reduced prematurity: 2018.

Race	Expected premature births	Actual premature births	Difference	Cost Savings per birth	Savings
Black	8.99	10	–1.01	$64,669	($65,262)
White	1.87	0	1.87	$64,669	$121,116
Other	1.16	1	0.16	$64,669	$10,119
Total	12.02	11	1.02		$65,973

Table A6. Expected cost savings due to reduced prematurity: 2019.

Race	Expected premature births	Actual premature births	Difference	Cost savings per birth	Savings
Black	5.86	8	–2.14	$66,050	($141,551)
White	0.81	1	–0.19	$66,050	($12,475)
Other	1.30	0	1.30	$66,050	$86,118
Total	7.97	9	–1.03		($67,907)

Table A7. Expected cost savings due to reduced prematurity: 2020.

Black	12.45	5	7.45	$67,831	$505,484
White	2.57	0	2.57	$67,831	$174,526
Other	1.47	3	−1.53	$67,831	($103,452)
Total	16.50	8	8.50		$576,559

Table A8. Expected cost savings due to reduced prematurity: 2021.

Black	11.79	8	3.79	$69,871	$264,665
White	4.17	3	1.17	$69,871	$81,618
Other	2.01	2	0.01	$69,871	$803
Total	17.97	13	4.97		$347,086

Table A9. Expected cost savings due to reduced prematurity: 2022.

Black	18.55	17	1.55	$71,844	$111,282
White	4.25	3	1.25	$71,844	$89,901
Other	3.18	3	0.18	$71,844	$12,718
Total	25.98	23	2.98		$213,901

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Article

Sustainable developments goals in the Arab region

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Abstract: This paper is devoted to the sustainable development goals in the Arab region. The author explored the most recent data provided by the Sustainable Development Report 2024, using the SDG index score to track the achievement progress in each Arab country and for each of the 17 goals. The results show that the Arab region achieved an overall SDG index score of nearly 62, less than the world average SDG index score (66.3). The low performance of low-income countries is obviously explained by conflicts, drought, the Covid-19 pandemic, economic crises, and political instability. Unexpectedly, however, high-income countries also contribute to the low performance in terms of SDG's achievement. Zero hunger (SDG2) is one of the most important SDGs that Arab countries can't reach by 2030, but Arab countries are facing significant and major challenges in many other essential SDGs like no poverty (SDG1), good health and wellbeing (SDG3), quality education (SDG4), gender equality (SDG5), clean water and sanitation (SDG6), decent work and economic growth (SDG8), and peace, justice and strong institutions (SDG16).

Keywords: sustainable development goal; target; Arab region; index; score; achievements

1. Introduction

Following the report of the United Nations World Commission on Environment and Development published in 1987 (also known as the Brundtland report) [1], a large number of publications were dedicated to sustainable development during the last three decades. Authors from different disciplines (economy, health, education, agriculture, ecology, sociology, health, epidemiology, statistics, ect.) dealt with "sustainability" in terms of definition, conceptualization, dependence on different contexts, frameworks, achievements, assessment, etc. [2–10].

Sustainable development is obtained through the interaction between economical, social and environmental components, often called the "three pillars of sustainability". In 2019, Purvis et al. [11] carried out a review exploring the conceptual origins of the three pillars of sustainability. They reviewed more than 130 references from the historical literature dealing with sustainability yielded by the interconnection between economical, social and environmental components. They stressed that sustainability, which is ubiquitous, is often represented by three circles (intersecting or concentric) or by three lateral pillars (**Figure 1**) and concluded that: "*Nowhere have we found a theoretically rigorous description of the three pillars. This is thought to be in part due to the nature of the sustainability discourse arising from broadly different schools of thought historically. The absence of such a theoretically solid conception frustrates approaches towards a theoretically rigorous operationalization of 'sustainability'.*"

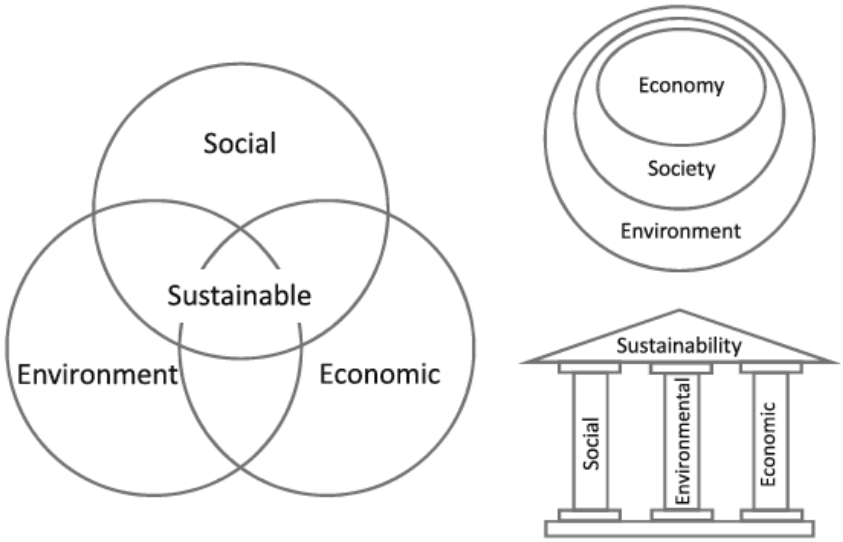

Figure 1. Sustainability is represented by three intersecting or concentric circles and by three lateral 'pillars'.

The most used definition of sustainable development was given by the United Nations as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*". This definition appeared for the first time in the Brundtland report, which stressed the link between economic growth, poverty and the environment [1].

Extending their commitments towards the achievement of the Millennium Development Goals (MDGs), which covered the period 2000–2015, the United Nations Member States unanimously adopted in 2015 the 2030 agenda of "Sustainable Development Goals (SDGs)" aiming at ending poverty, improving people's health at all ages, reducing all kinds of inequalities ("no one is left behind"), ensuring human well-being and encouraging economic growth that creates decent jobs for men and women, especially in developing countries, while protecting the environment and limiting waste. The agenda 2030 set 17 goals to be achieved by 31 December 2030 (**Table 1**) [12].

Table 1. Sustainable development goals to be achieved by 31 December 2030.

No	Goal	No	Goal
1	No poverty	10	Reduce inequality
2	Zero hunger	11	Sustainable cities and communities
3	Good health and wellbeing	12	Responsible consumption and production
4	Quality education	13	Climate action
5	Gender equality	14	Life below water
6	Clean water and sanitation	15	Life and Land
7	Affordable and clean energy	16	Peace, justice and strong institutions
8	Decent work and economic growth	17	Partnerships for the goals
9	Industry, Innovation and Infrastructure		

Pragmatically, achievement of the 17 SDGs is monitored through 232 indicators related to 169 SDG targets. For example, the SDG 3 hoping "to ensure healthy lives and to promote wellbeing for all ages" requires that all countries achieve the following targets [13]:

- Maternal mortality: Reduce the global MMR to less than 70 (deaths per 100,000 live births).
- Neonatal and child mortality: End preventable deaths of newborns and children under 5 years of age by reducing NMR to < 12 (deaths per 1000 live births) and U5MR < under 25 (deaths per 1000 live births).
- Infectious Diseases: End the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases, and combat hepatitis, water-borne diseases and other communicable diseases.
- Non communicable diseases: Reduce by 1/3 premature mortality from NCDs through prevention and treatment, and promote well-being and mental health.
- Substance abuse: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
- Road traffic: Reduce by 50% the number of global deaths and injuries caused by road traffic accidents.
- Sexual and reproductive health: Allow universal access to sexual and reproductive health-care services, including family planning, information and education, and the integration of reproductive health into national strategies and action programs.
- Universal health coverage: Achieve UHC, including access to the main health-care services and to affordable, effective, safe, and essential medicines and vaccines for all.
- Environmental health: Reduce significantly the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

In 2023, the Arab world or more precisely, the League of Arab States had a total population of around 473 million gathered in the following 22 countries: Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the UAE and Yemen. Arab countries have many dissimilarities and similarities. On the one hand, populations living in these countries share religion, language and culture; on the other hand, they present social, economic and political differences [14]. For instance, the Human Development Report published by UNDP in 2024 shows huge gaps between the 22 countries (**Figure 2**). Indeed, the rich Arab countries of the Gulf Cooperation Council (GCC) (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and Oman) are ranked in the world's top 60 countries with a very high HDI, while the low-income countries (Djibouti, Mauritania, Somalia, Sudan and Yemen) are at the bottom with a low HDI (Somalia being the country with the lowest HDI among 193 countries). Moreover, the inequality-adjusted HDI (IHDI) shows that Arab countries are characterized by high inequalities in terms of human development and its components. The overall loss due to inequality in HDI is between 20% and 30% in Algeria (21.1%), Tunisia (21.6%), Egypt (22.9%), Iraq (22.9%) and Morocco (27.2%), while Yemen (32.8%), Sudan (35.9%), Mauritania (35%), and Djibouti (33.8%) lose one-third or more of their HDI due to inequality. Finally, the greatest rate

of loss due to inequality in HDI components is registered in Comoros, which loses nearly half of its HDI (43%) [15].

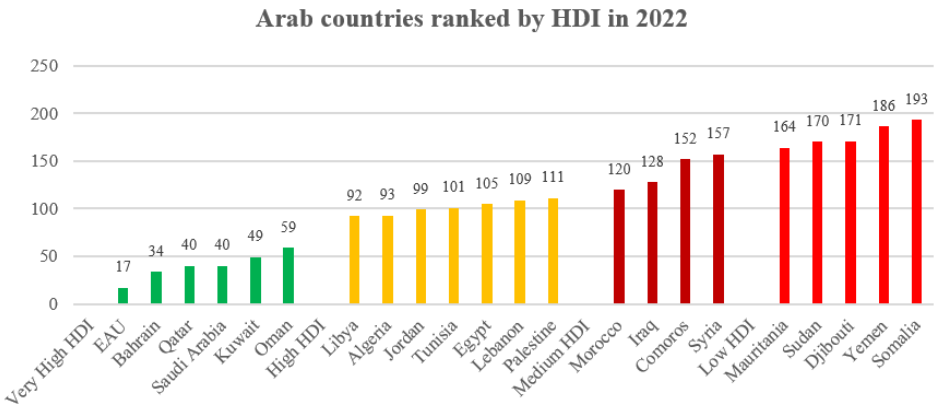

Figure 2. Arab countries subdivided into four sub-groups according to the HDI rank.
Note: In the first (green) group, countries have very high HDI and they are ranked in the top 60 countries, while in the last (red) group, countries have low HDI and they are ranked at the bottom.
Source: UNDP [15].

As indicated by UNESCWA, although many Arab countries made significant progress in terms of primary and secondary school enrolment, there are still barriers hindering the achievement of universal education in the Arab region [16]. Substantial problems are raised by the inequalities between boys and girls, rural and urban children, as well as between children living in rich and poor families. Gaps in primary school enrolment show a gender inequality of 11%, 10% and 8% in Iraq (98% for boys vs. 87% for girls), Yemen (88% for boys vs. 78% for girls), and Djibouti (61% for boys vs. 53% for girls) respectively. Similarly, primary school attendance rates indicate large differences between the richest and poorest children living in Sudan (94% vs. 48%), Yemen (90% vs. 56%), Comoros (95% vs. 72%), Morocco (97% vs. 77%) and Iraq (98% vs. 79%). Finally, in most Arab countries, urban children are more likely to highly attend primary school than their counterparts living in rural areas. For instance, the low primary school net attendance rate in Somalia is exacerbated by the huge difference between urban (38.6%) and rural (11.2%) areas [16]. Moreover, in addition to the problems of school enrolment and attendance, Arab countries also suffer from a bad quality of education. Indeed, the results of well-known international surveys show that Arab countries perform very badly [17–19]. For instance, (1) the "PISA 2022 Worldwide Ranking" published the average score obtained in mathematics, science and reading by 15-year-old students from 81 countries worldwide. Of the six Arab countries that participated in PISA 2022, none was ranked in the top group; the UAE (426.7) and Qatar (414) were placed in the mid-score group, while Saudi Arabia (387.3), Palestine (361.3), Jordan (359.3) and Morocco (356.3) were at the bottom of the list [17]. (2) Similarly, TIMSS (Trends in International Mathematics and Sciences Study) is an international survey that compares the performance of primary and secondary school students in a large number of countries worldwide based on the results obtained in mathematics and science (physics, chemistry and natural sciences). According to TIMMS 2019 results, Lebanon, Jordan, Egypt, Oman, Kuwait, Saudi Arabia and Morocco (the last country among the 39 participating countries) were ranked among the eight least performing countries in

mathematics grade 8, and similar results were registered for mathematics grade 4 and science grade 4 and grade 8 [18]. (3) Finally, the results on reading published in 2021 by PIRLS (Progress in International Reading Literacy Study) indicate that Oman, Jordan and Egypt were among the last 4 countries at the bottom of the list covering 43 countries worldwide [19].

According to a report released by UNESCWA in 2022 on "Inequality in the Arab region: A Ticking Time Bomb", the Arab region ranks as the most unequal region in the world [20].

In 2023, Boutayeb showed that territorial disparities, health inequities and social inequalities exist within and between Arab countries in terms of wealth, health and education measured by different indicators such as the Gini index, human development index (HDI), maternal mortality ratio (MMR), under-five mortality rate (U5MR), life expectancy, nutritional status, employment rate, gender index, literacy rate, schooling years and others [21]. For instance, the GDP per capita in current prices (USD) in Qatar (USD72760) is 160 times higher than in Yemen (USD 455) [22]. Similarly, the maternal mortality ratio is less than 10 deaths per 100,000 live births in Kuwait (7), Qatar (8) and UAE (9) while it reaches hundreds in the following low-income countries: Somalia (621), Mauritania (464), Sudan (270), Djibouti (234), Comoros (217) and Yemen (183) [23]. These unbelievable gaps are illustrated by a multitude of other indicators [21].

2. Materials and methods

This paper is based on data provided by the United Nations on tracking achievements and trends of Sustainable Development Goals in all UN member States. The progress towards SDGs achievement is monitored by the SDG index score which has a value between 0 and 100. On this scale, a SDG index reaching the value 100 means that the corresponding SDG is completely achieved while the gap between a country's SDG index and 100 indicates the challenges remaining to reach the SDG optimal value desired. A comparison can be made between two countries for individual SDGs and for an overall performance over the 17 SDGs. However, precaution is needed when interpreting the overall ranking of countries according to their SDG index score. Our analysis is based on the SDG index scores provided by the UNDP Sustainable Development report 2024 [24]. Data provided by governments may suggest some limitations related to missing, unreliable or biased data.

3. Results

3.1. Trends and progress in achieving SDGs in each Arab country

The rate of SDG's achievement by each of the 193 UN Member States is regularly updated and published online by the UNDP Sustainable Development report [24]. As summarized in **Table 2**, the most recent (available) data provided by the Arab countries are presented according to 4 levels of achievement: (1) SDGs achieved; (2) challenges remain; (3) significant challenges remain; and (4) major challenges remain. It is regrettable to see that data on poverty (SDG1), inequality (SDG10) and peace,

justice and strong institutions (SDG16) are not available in all countries belonging to the GCC, except the UAE.

Table 2. Tracking the rate of SDGs achievement by Arab countries.

Country	SDGs Achieved	Challenges Remain in SDGs	Significant Challenges remain	Major challenges remain	Information unavailable	SDG Index score	Index Rank /166
Tunisia	1	4, 11, 12, 13, 17	3, 6, 9, 10	2, 5, 7, 8, 14, 15, 16		72.53	60
Morocco		1, 12, 13, 17	2, 4, 6, 9, 10, 11	3, 5, 7, 8, 14, 15, 16		70.85	69
UAE	1, 4, 10	3, 9	5, 7, 16, 17	2, 6, 8, 11, 12, 13, 14, 15		70.52	70
Algeria	1, 10	12, 13, 17	2, 6, 9, 11, 14	3, 4, 5, 7, 8, 15, 16		70.47	71
Egypt		1, 12, 13	4, 5, 6, 7, 9, 10, 17	2, 3, 8, 11, 14, 15, 16		69.10	83
Jordan	1	12, 13, 14	7, 9, 10, 16, 17	2, 3, 4, 5, 6, 8, 11, 15		69.06	85
Oman		8, 17	3, 4, 9, 14, 15	2, 5, 6, 7, 11, 12, 13	1,10,16	66.11	100
Qatar		3, 4, 9, 16	5, 11, 14, 17	2, 6, 7, 8, 12, 13, 15	1,10	64.93	102
Saudi Arabia		17	3, 4, 6, 8, 9, 16	2, 5, 7, 11, 12, 13, 14, 15	1,10	64.91	103
Iraq		1, 10	4, 9, 12, 13, 14, 17	2, 3, 5, 7, 8, 11, 15, 16		64.18	108
Lebanon	1	4, 9, 10	6, 12	2, 3, 5, 7, 8, 11, 13, 14, 15, 16, 17		63.89	110
Kuwait		3	4, 5, 7, 8, 9, 15, 16, 17	2, 6, 11, 12, 13, 14	1,10	63.76	111
Bahrain		3,8	4, 5, 7, 9, 17	2, 6, 11, 12, 13, 14, 15	1,10,16	63.56	113
Syria	13	1, 10, 12	6, 11	2, 3, 4, 5, 7, 8, 9, 14, 15, 16, 17		60.60	127
Mauritania		10, 12, 13	1, 17	2, 3, 4, 5, 6, 7, 8, 9, 14, 15, 16		58.17	132
Comoros	13		11, 17	1, 2, 3, 4, 5, 6, 7, 9, 10, 14, 15	8,12,16	52.38	153
Djibouti		11, 13	1, 12	2, 3, 4, 5, 6, 7, 8, 9, 11, 14, 15, 17	16	51.58	157
Sudan	13	12	7, 10	1, 2, 3, 4, 5, 6, 8, 9, 11, 14, 15, 16, 17		49.91	159
Yemen	12, 13		10, 17	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14, 15, 16		46.87	163
Somalia	12, 13		11	1, 2, 3, 5, 6, 7, 8, 9, 14, 15, 17	4,10,16	45.42	164

Source: UNDP Sustainable Development Report: Country profiles. https://dashboards.sdgindex.org/profiles [24]. SDGs are either achieved or with remaining challenges or significantly challenging or under major challenges.

3.2. Overall achievement of SDGs in Arab countries

In the 20 Arab regions (no data is available for Libya or Palestine), the overall achievement rate in the 17 SDGs varies from a minimum of 45.42 in Somalia to a

maximum of 72.53 in Tunisia (**Table 3**). None of the Arab countries are ranked in the top 50 performing countries and five Arab countries are in the bottom 14 performing countries. Globally, the Arab region achieved an overall SDG index score of nearly 62, while the world SDG index score is 66.3.

Table 3. Arab countries ranked by SDG index score.

Rank /167	Country	SDG index	Rank /167	Country	SDG index	Rank /167	Country	SDG index
60	Tunisia	72.53	102	Qatar	64.93	132	Mauritania	58.17
69	Morocco	70.85	103	S.A	64.91	153	Comoros	52.38
70	UAE	70.52	108	Iraq	64.18	157	Djibouti	51.58
71	Algeria	70.47	110	Lebanon	63.89	159	Sudan	49.91
83	Egypt	69.15	111	Kuwait	63.76	163	Yemen	46.87
85	Jordan	69.06	113	Bahrain	63.56	164	Somalia	45.42
100	Oman	66.11	127	Syria	60.60		Arab world	61.94

Source: https://dashboards.sdgindex.org/ [24].

As indicated by **Figure 3**, the 20 Arab countries can be subdivided into three sub-groups according to the overall achievement rate in the 17 SDGs. A first group gathering seven countries with relatively high regional SDG index scores between 66.11 and 72.53, a set of seven countries achieving SDG index scores between 60.6 and 64.93, and finally a third group bringing together the 6 low-income countries (Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen) with the lowest regional performance.

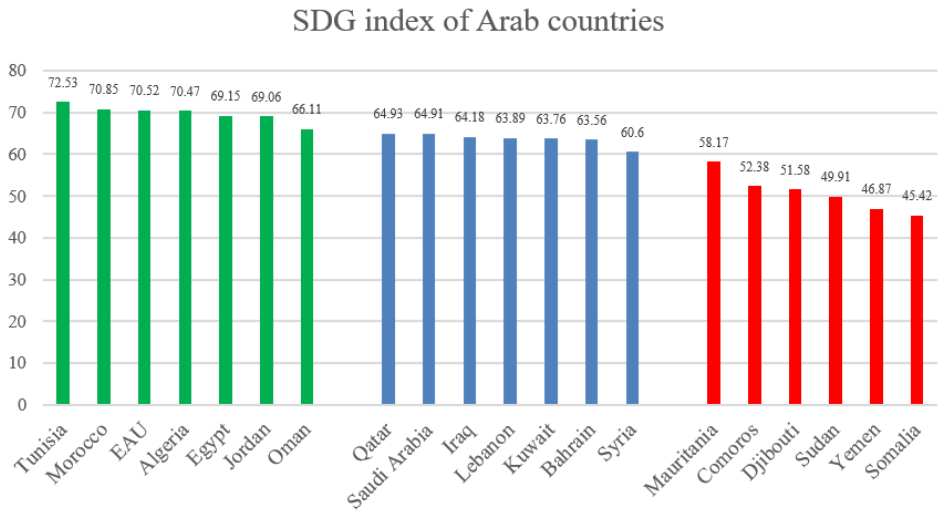

Figure 3. Arab countries ranked by their SDG index.

Note: The first (green) set is grouping the seven countries with the highest regional SDG index score, while countries with the least regional SDG index score are gathered in the last (red) group. Source: Sustainable Development Report: Country profiles [24].

4. Discussion

Globally, the Sustainable Development report 2024 stresses that the SDG progress was slow before the Covid-19 pandemic and then stagnated since 2020. Consequently, it is estimated that hardly 16% of the SDG targets are on track and

hence, none of the 17 SDGs will be achieved by 2030. Moreover, some SDGs are even showing a reversal of progress [24].

In the Arab region, with just six years remaining before the deadline, very few SDGs have been achieved by individual countries so far, while most countries are facing significant and major challenges to reach SDG's goals by 2030. Indeed, each of the 20 Arab countries has eleven or more SDGs with significant or major challenges, and seven countries (Comoros, Djibouti, Mauritania, Somalia, Sudan, Syria, Yemen) are facing eleven or more major challenges. Consequently, achieving the 17 SDGs in the Arab region seems very difficult if not impossible. More importantly, the whole region is far away from achieving essential SDGs like no poverty (SDG1), zero hunger (SDG2), good health and wellbeing (SDG3), quality education (SDG4), gender equality (SDG5), clean water and sanitation (SDG6), decent work and economic growth (SDG8), peace, justice and strong institutions (SDG16).

As indicated by **Figure 3**, ranking the 20 Arab countries by their overall SDG index score leads to three sub-groups. In the first group, seven countries (Algeria, Egypt, Jordan, Morocco, Oman, Tunisia, and UAE) have realized two-thirds or more of the desired achievements for the whole set of 17 SDGs. In this group, the United Arab Emirates has already achieved the three SDGs: "No poverty (1)", "Quality education (4)" and "Reduce inequality (10)". Algeria also achieved the two SDGs (1 and 10), while Oman and Tunisia achieved the first SDG. The least developed countries and/or those affected by conflicts (Comoros, Djibouti, Mauritania, Somalia, Sudan and Yemen) constitute a third group seriously lagging in the overall achievement of SDGs. Although four of the six countries have achieved the SDG 13 (Climate action) and two of them have also achieved the SDG 12 (Responsible consumption and production), these low-income countries are facing major challenges in achieving the remaining SDGs. Between the two previous groups, there is an intermediate mixed group containing countries of the Gulf Cooperation Council (GCC) (Bahrain, Kuwait, Qatar and Saudi Arabia) and low- or middle-income countries (Iraq, Lebanon and Syria). In this second group, Lebanon and Syria have respectively achieved SDGs 1 and 13 (No poverty and Climate action), while the seven countries are facing significant and major challenges in 77% of cases.

"Zero hunger (SDG 2)" is one of the most important SDGs challenging the Arab region, which is off-track to meet nutrition targets and food security. Indeed, an alarming report was published in 2024 by the following six UN organizations: Food and Agriculture Organization (FAO), the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), the International Fund for Agricultural Development (IFAD), the United Nations Economic and Social Commission for Western Asia (ESCWA) and the World Food Programme (WFP) [25]. This report indicates that the Arab region is suffering from the double burden of hunger-food insecurity and overweight-obesity. Indeed, as illustrated by **Tables 4** and **5**, the following striking statistics were given for the year 2023: (1) More than 60 million people representing around 14% of the population in Arab countries faced hunger; (2) severe or moderate food insecurity affected 186.5 million people (39.4%) of whom nearly 40 million people (15.4%) were severely food insecure; (3) nearly one-third of the population living in Arab countries (151.3 million) were unable to afford a healthy

diet; (4) nearly 20% and 7.1% of children under five years of age were suffering from stunting and wasting respectively; (5) overweight in children under five years of age reached 9.5% in the Arab region, nearly double the world average (5.6%), with Libya, Tunisia and Egypt registering respectively 28.7%, 19% and 18.8%; (6) obesity in adults 18 years old or over was more than twice as high in the Arab region (32.1%) than the global average (15.8%), with Egypt, Qatar and Kuwait registering respectively 44.3%, 43.1% and 41.4%, and finally; (7) anemia affected more than one-third of women aged 15–49 years and living in Arab countries, with the highest prevalence of anemia registered in Yemen (61.5%), Mauritania (43.3%) and Somalia (43.1%).

Table 4. Undernourishment, food insecurity and healthy diet affordability in the Arab region.

	Under-nourishment		**Severe Food-insecurity**		**Severe or moderate Food-insecurity**		**Unable to afford healthy diet**	
	Number (Millions)	**%**	**Number (Millions)**	**%**	**Number (Millions)**	**%**	**Number (Millions)**	**%**
Low-income countries	38.5	31.1	68.5	29.0	84.9	68.5	No data	
Lower-middle-income countries	15.6	7.1	29.5	9.8	65.1	29.5	65.7	30.2
Upper-middle-income countries	10.5	15.2	38.5	15.8	26.6	38.5	16.6	24.3
High-income countries	1.5	2.5	16.7	6.8	9.9	16.7	No data	
Countries affected by conflict	46.5	26.4	44.1	25.0	103.9	58.9	70.6	41.2
Countries not affected by conflict	19.6	6.6	28.6	9.6	82.7	27.8	83.7	28.5
Arab States	66.1	14.0	39.4	15.4	186.5	39.4	151.3	32.6
World	733.4	9.1	28.9	10.7	2325.5	28.9	2826.3	35.4

Table 5. Prevalence of stunting, wasting, overweight-obesity and anemia in the Arab region.

	Children under 5 years of age (%)			**Adults 18 years old or over (%)**	**Women aged 15-49 years (%)**
	Prevalence of stunting	**Prevalence of wasting**	**Prevalence of overweight**	**Prevalence of obesity**	**Prevalence of anemia**
Low-income countries	31.1	14.6	3.4	19.7	43.9
Lower-middle-income countries	15.6	5.3	14.2	33.8	30.6
Upper-middle-income countries	13.3	4.1	8.5	39.7	29.0
High-income countries	10.8	5.0	9.5	38.6	27.1
Countries affected by conflict	26.5	10.4	4.8	26.2	39.2
Countries not affected by conflict	14.7	5.0	13.3	34.7	29.9
Arab States	19.9	7.1	9.5	32.1	33.2
World	22.3	6.8	5.6	15.8	29.9

Source: FAO, IFAD, UNICEF, WFP, WHO and ESCWA [25].

Beside the devastating effect of the Israeli occupation, the UNESCWA indicates that "*Compared to other regions, the Arab region has been the most conflict-affected in recent years*" [26]. It is estimated that 4 out of 10 Arab countries experienced internal conflicts during the period 2009–2013. In the Arab region, conflicts and war are particularly significant drivers of undernourishment and food insecurity. The prevalence of undernourishment in countries affected by conflict (26.4%) is four times

higher than in countries not affected by conflict (6.6%). In 2023, the most affected countries by undernourishment were Somalia (51.3%), Yemen (39.5%), Syria (34%) and Comoros (16.9%). However, the recent conflicts in Sudan and the war in Palestine and Lebanon will undoubtedly increase the magnitude of undernourishment and food insecurity. Gaza is a clear illustrative example. According to the United Nations "Integrated Food Security Phase Classification (IPC)", during the period November 2024 and April 2025, about two million people, representing 90% of the Gaza population, will be in IPS Phase 3 (Crisis) or above, of which 41% and 16% will respectively be in Emergency (IPC Phase 4) and Catastrophe (IPC Phase 5) [27].

In 2024, Wang et al. assessed the impact of armed conflict on the progress of achieving 17 sustainable development goals [28]. They indicated that, while armed conflicts are particularly affecting development areas linked to SDGs such as education, healthcare and infrastructure, they slow the achievement of all 17 SDGs and delay progress in over half of the SDGs by more than 5% [28]. In the Arab region, a report released by the International Rescue Committee (IRC) and the Overseas Development Institute (ODI) in 2019 showed that "millions of 'people caught in crisis'—people living in conflict, and/or who are displaced within their own countries or across borders—are in fact being left behind" [29]. They stressed that SDGs will not be achieved and the credibility of the international community undermined unless world leaders are committed to acting urgently so that people caught in crisis are not forgotten [29]. UNESCWA estimated that, in 2022, nearly 2% of people in the Arab region were refugees, almost fivefold higher than the global average [30]. Consequently, conflicts may explain, at least partially, why little achievement in SDG targets is registered in countries like Somalia, Sudan, Syria and Yemen (and also the unavailability of SDG's data in Libya and Palestine). It is, however, surprising to see that rich countries of the GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE) have not achieved high SDGs scores while they are ranked in the top 50 countries with the highest GDP per capita and the highest human development index (**Table 6**). Indeed, of the 6 GCC countries, 6, 5, 4 and 3 of them are facing (red) major challenges in SDG2-SDG12-SDG13, SDG6-SDG11, SDG14-SDG15 and SDG7 respectively (**Table 2**).

Table 6. the rank of GCC countries according to SDG Index, GDP per capita and HDI.

Country	GDP Per capita rank	HDI rank	SDG index rank
Bahrain	19	34	113
Kuwait	23	49	111
Oman	42	59	100
Qatar	5	40	102
Saudi Arabia	20	40	103
UAE	6	17	70

Source : Worldometer [31], UNDP [15], SDG Reports [24].

As indicated in the introduction section, there is an interaction between the "three pillars of sustainability" (economical, social and environmental components) and more generally, between the 17 SDGs in the Arab region and in other regions of the

world. Consequently, Arab policy makers should consider the synergistic effect between different components of sustainable development in order to optimize the overall yield. The relation between different components of sustainable development, like economic growth, health, technological innovation, and environmental degradation was investigated by many authors [32–37]. Recently, Yadav and Asongu [32] used a wavelet-enhanced quantile regression approach to examine the influence of environmental, social, and governance (ESG) scores on the resilience of financially distressed Indian companies. Their findings revealed "that high ESG scores significantly bolster company resilience during financial distress, highlighting the dual benefits of sustainable practices on corporate stability and environmental impact [32]. Hashmi and Alam [33] explored the dynamic relationship among environmental regulation, innovation, CO_2 emissions, population, and economic growth in OECD countries. Khan [34] analyzed the crucial effect of poverty, unemployment, and environmental degradation on the achievement of sustainable development. He focused on ten developing countries in Asia and the Pacific and explored what he called "the three ZEROS" (zero net carbon emissions, zero poverty, zero unemployment). Khan and Awan [36] investigated the link between climate changes and human health expenditures. Saleem et al. [35] examined the impact of government effectiveness and technological innovation on economic growth and environmental degradation in Middle East & North Africa countries. They found a significant and positive relationship between innovation and CO_2 emissions while they indicated a significant and negative impact of government effectiveness on CO_2 emissions. Their study "highlights that synergizing innovation with government effectiveness is essential for attaining sustainable economic growth in the studied are". Bekun et al. [37] considered a carbon-function framework in Turkey to explore the causality connection between disaggregated energy consumption, environmental tax and economic growth. Their findings show that Turkey's Load Capacity Factor (LCF) is driven by economic growth, indicating that energy efficiency is linked to economic performance. Nonrenewable energy hinders LCF, while renewable energy boosts it. Furthermore, population growth positively affects energy efficiency, but environmental taxes have minimal impact, suggesting the need for policy reforms. UN experts suggested that "governments must seek win-win synergies by tackling climate and sustainable development crises together" [38].

5. Conclusion

This paper shows that the Arab region achieved less than the world average in terms of SDG targets. Unfortunately, the low level of achievement is not only due to the difficult problems experienced by low-income countries (war, conflicts, the Covid-19 pandemic, drought, economic crisis, etc.), it is also the result of a low performance of the rich countries of the Gulf Cooperation Council.

As recommended by the "UN Sustainable Development Solutions Network for the Summit of the Future" [24], sustainable development is the commitment towards People, Peace, Planet, Prosperity, and Partnerships. First of all, means for good health and well-being should be available to and accessible by all people worldwide, leaving no person or nation behind; secondly, peace and security must prevail at all levels,

including households, countries and world regions, while violence, conflicts and wars must be banned; thirdly, there are hundreds of different nations and billions of people, but our planet is unique and consequently, we must preserve its generous wealth for the present and the future generations; fourthly, the contributions of education and technology must be encouraged for a better world and not for its destruction; finally, the previous points underlined should constitute a plateform for a wise and honest collaboration involving individuals, academics, governments and all other possible stakeholders.

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Review

Study of the concept and dimensions of gender-based violence and its connection to adolescence and its link to education

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Abstract: Gender-based violence is a global issue that, in addition to claiming thousands of lives worldwide each year, has serious physical, psychological, and social consequences for the victims. The synergy between gender-based violence and adolescence is a concerning phenomenon, as adolescents are vulnerable to abusive behaviors that they may normalize within romantic relationships. During this stage, ideas about love and relationships are still being formed, which may lead young people to not recognize certain behaviors as gender-based violence. This article provides a literature review on the different types of gender-based violence, focusing on adolescence. Additionally, the main risk factors and the consequences for the victims are analyzed. Finally, preventive lines of work in various areas are proposed, with particular emphasis on coeducation and highlighting the importance of early identification of violence indicators in adolescent relationships, such as control, jealousy, emotional manipulation, and cyberbullying.

Keywords: gender-based violence; adolescence; gender; equality; coeducation

1. Introduction

Gender-based violence is a global issue that claims thousands of lives each year worldwide. According to data from the Ministry of Equality, in 2023, the number of women victims of gender-based violence in Spain reached 194,658, representing a 10.3% increase compared to 2022. Reports of such violence also rose, totaling 199,282, which is a 9.46% increase from the previous year. On average, 533 new victims were recorded daily. The rates of gender-based violence per 10,000 women were notably higher in regions such as the Balearic Islands and Murcia [1]. This phenomenon is a complex social and cultural issue, a structural problem with deep historical and cultural roots that perpetuates gender inequalities within society.

The synergy between gender-based violence and adolescence is a concerning phenomenon, as adolescents are particularly vulnerable to abusive behaviors that may become normalized within romantic relationships. During this developmental stage, notions of love and relationships are often still forming, which can lead young individuals to fail to recognize certain behaviors as gender-based violence. Gender-based violence in adolescence, similar to that experienced by adults, has severe short- and long-term consequences, affecting not only physical health but also mental well-being. Many victims experience anxiety and depressive episodes, substance abuse, disruptive behaviors, and even suicidal ideation. This adversely impacts future relationship dynamics, where issues such as partner violence and the perpetration and/or victimization of sexual violence may arise [2].

In 2010, a survey titled "Equality and Prevention of Gender-Based Violence in Adolescence" was conducted to assess the experiences of adolescent girls regarding partner violence. The results indicated that 3.43% of girls reported having been physically assaulted, 4.64% felt coerced into sexual behaviors they did not wish to engage in, and 6.52% experienced harassment through messages via the internet or mobile devices [3]. Similarly, concerning data emerged regarding male respondents, with 2.51% admitting to having physically assaulted their partner and 4.58% acknowledging having pressured their partner into unwanted sexual activities; additionally, 3.25% reported having harassed their partner through mobile or internet platforms [3]. These data lead us to consider the variables that are perpetuating, even increasing these percentages, despite the public policies and educational actions carried out.

The main objective of this work is to analyze the different typologies of gender-based violence, understand the cycle of violence, and explore how it manifests in teenage relationships. To do so, both theoretical approaches and practical examples will be used to illustrate how these dynamics affect young people in their social and emotional relationships. Additionally, risk factors that may contribute to the development of violent behaviors will be examined, as well as possible prevention and intervention strategies.

2. Conception of gender-based violence

In 1993, the United Nations General Assembly, in its Declaration on the eradication of violence against women, recognized the urgent need to apply the rights and principles related to balance, stability, independence, integrity, and dignity of all individuals, aimed at reinforcing the elimination of all forms of discrimination against women since this constitutes an impediment to achieving equality. It also scrutinized that violence against women is a manifestation of the unequal power dynamics between men and women, which have led to the subjugation and discrimination against women by men. It asserted that violence against women is one of the social mechanisms through which women are forced into situations of submission to men, defining it as "any act of violence based on the female gender that causes or may cause physical, sexual, or psychological harm to women, as well as the threat of such acts, coercion, or unjustified deprivation of independence, regardless of whether it occurs in the public or private sphere" [4].

In this regard, it is essential to distinguish between the concepts of "gender-based violence" and "domestic violence," as these two terms may initially seem similar, but upon closer examination, it becomes evident that they refer to different contexts. In the former case, the perpetrator must have or have had an emotional interaction or bond with the victim, such as being or having been partners, dating, married, or involved in another analogous relationship. Conversely, domestic violence encompasses any degrading action or omission perpetrated by one or more members of a family unit against others; this situation includes violence against all individuals within the family circle [5].

The United Nations defines gender-based violence as "any act of violence based on gender that results in, or is likely to result in, physical, sexual, or mental harm or

suffering to women, including threats of such acts, coercion, or arbitrary deprivation of liberty, whether occurring in public or private life" [4].

The World Health Organization characterizes gender-based violence, particularly against women, as "a significant and severe global health issue. It includes acts such as physical, sexual, emotional, or psychological abuse, as well as intimate partner violence or sexual violence, which result in harmful consequences for women's health and well-being [6].

Lorente-Acosta, an expert on gender-based violence, defines it as "violence perpetrated against an individual based on their gender, primarily directed toward women, simply for being women, within a context of inequality between men and women." According to this author, this form of violence is a manifestation of historically unequal power relations between men and women [7].

Authors such as Boira et al. [8], refer to the concept as "any form of violence directed at a person based on their gender or sex, including physical, sexual, psychological, or economic violence, which occurs in contexts of power inequality between men and women." They emphasize the intersection of social and cultural factors that perpetuate this violence.

Lagarde, a prominent Mexican anthropologist and feminist, defines gender-based violence as "a set of behaviors, actions, and omissions that harm women physically, emotionally, sexually, economically, and symbolically, imposed by the aggressor as an expression of gender superiority and the control they seek to exert over women" [9].

These definitions and references highlight the complexity and multidimensionality of gender-based violence, underscoring its impact on women and the necessity of addressing this phenomenon from multiple fronts, including health, justice, and human rights.

In the following section, we will explore the various forms in which gender-based violence manifests, distinguishing between physical, psychological, sexual, and economic violence. It is essential to understand each of these typologies to comprehend the scope of gender-based violence and its effects on victims.

3. Typology of gender-based violence

Gender-based violence encompasses various forms of abuse aimed at controlling and dominating the victim, typically women, within a context of power inequality. The most common types, according to various authors and studies, include [10–12]:

3.1. Physical violence

It is perhaps the most visible and recognized form of gender-based violence. It refers to any act that causes bodily harm or physical suffering to the victim. This type of violence includes, but is not limited to, hitting, pushing, kicking, strangulation, burning, and the use of weapons to inflict harm. Physical violence not only leaves marks on the victim's body but also has profound psychological effects, including fear, anxiety, and loss of self-esteem [13].

It is important to note that physical violence can escalate in severity over time, beginning with seemingly minor acts such as pushing or slapping and progressing to more severe and potentially lethal attacks. Additionally, physical violence is often

employed as a mechanism of control, whereby the aggressor seeks to dominate the victim through fear and intimidation [14]. This physical control frequently intersects with other types of violence, such as psychological or economic abuse, to reinforce the aggressor's power over the victim. As of 2024, 32 women have been murdered in Spain due to gender-based violence.

3.2. Psychological or emotional violence

Psychological violence primarily employs fear as a weapon of coercion. It encompasses insults, threats, humiliation, and isolation that damage the victim's self-esteem and emotional well-being. Sampedro notes that this form of violence is difficult to detect and can have devastating long-term effects [15].

Psychological violence is one of the most insidious forms of gender-based violence, as it is not always visible to others, yet it can be profoundly damaging to the victim. This type of violence involves the use of behaviors and words aimed at humiliating, controlling, manipulating, or emotionally destabilizing the victim through belittlement, threats, social isolation, emotional blackmail, and the manipulation of reality to make the victim doubt their own judgment or sanity (a tactic known as "gaslighting"). Over time, these verbal assaults erode the victim's confidence and self-esteem, leading them to feel trapped and dependent on the aggressor [16].

Psychological violence is particularly dangerous because it can persist over time without being detected, both by the victim and their surroundings, complicating intervention and support efforts. Furthermore, it often serves as a precursor to physical violence, as the aggressor uses emotional abuse to weaken the victim before resorting to physical force.

3.3. Sexual violence

Sexual violence refers to any form of coercion or manipulation aimed at obtaining non-consensual sexual relations. Authors such as Kelly explore the concept of the "continuum of sexual violence," which encompasses a range of behaviors from inappropriate comments to physical rape. In the context of gender-based violence, sexual violence can occur as sexual abuse within a relationship, where the aggressor forces their partner to engage in sexual acts against their will, using physical force, intimidation, or emotional blackmail [10,17].

It is also important to highlight the phenomenon of coercive "sexting," in which the victim is pressured to send intimate images that can later be used for blackmail. This trend is increasingly prevalent among younger individuals through social media [18].

Sexual violence is one of the most severe violations of human rights and represents an extreme manifestation of control and domination over the victim. In many cases, victims do not report these abuses due to fear of retaliation, social stigma, or a lack of confidence in the judicial system.

3.4. Economic violence

Some authors indicates that this type of violence entails absolute control over the victim's financial resources, limiting their ability to be autonomous or escape the abusive relationship. Economic violence is a form of abuse in which the aggressor

controls and manipulates the victim's economic resources to keep them dependent and subordinate. This type of violence includes restricting the victim's access to money, prohibiting them from working or studying, excessively controlling expenditures, accumulating debts in the victim's name, and withholding economic resources as a means of punishment or control [11,19].

Economic violence is particularly insidious because it may be less apparent than other forms of abuse, yet it has a devastating impact on the victim's autonomy and security. This type of violence often coexists with other forms of gender-based violence and contributes to perpetuating the cycle of abuse.

3.5. Symbolic violence

Defined by Bourdieu, symbolic violence is a subtle form of violence exercised through the media, advertising, or social discourse that perpetuates unequal gender roles and naturalizes the subordination of women [19]. Furthermore, as noted by Davila et al. [20], this type of violence underpins all other forms of violence.

3.6. Physical violence

This type of violence refers to the manipulation and harm inflicted through the victim's children or other close individuals, typically with the intent of increasing emotional suffering [21]. Vicarious violence causes irreparable harm and can be devastating for women. Since 2013, when the counting of such murders began, more than 40 girls and boys have been killed by their biological fathers or partners or ex-partners of their mothers, with the goal of permanently destroying the woman.

3.7. Institutional violence

Institutional violence refers to physical, sexual, psychological, or economic violence, among other types of symbolic violence, that is abusively perpetrated by agents and officials of the state in the course of their duties. This includes norms, protocols, institutional practices, neglect, and deprivations that harm individuals or groups of individuals. Institutional violence is characterized by the use of state power to inflict harm and reinforce established mechanisms of domination [22].

4. The cycle of violence

The cycle of gender-based violence is a model proposed by psychologist Walker to explain how violence develops and perpetuates in abusive relationships. This cycle consists of three main phases that repeat and intensify over time. Each phase is crucial for understanding the dynamics of abuse and why victims often remain in violent relationships [23].

1) Phase of tension accumulation: During this phase, the aggressor begins to exhibit signs of irritation, frustration, or anger towards the victim. Small incidents of emotional, psychological, or even physical abuse may occur. The victim, in turn, attempts to calm the aggressor or modify their own behavior to avoid a greater confrontation. Walker notes that victims often try to rationalize the aggressor's behavior, which contributes to the invisibility of the problem during this phase [23].

2) Phase of violent explosion: In this phase, the accumulated tension erupts in a more severe act of violence, which may be physical, psychological, sexual, or a combination of these. It is the moment when the aggressor releases all contained anger, and the victim experiences the abuse more directly and intensely. Walker and other authors, such as Stark, have documented how, in this phase, the victim feels completely powerless and terrified. The incident reinforces the perception that there is no escape [24].
3) Phase of reconciliation or "honeymoon": After the act of violence, the aggressor may show remorse, apologize, and promise that it will not happen again. During this phase, they may be affectionate and loving, leading the victim to believe that the abuse has ended and that the relationship will improve. However, for the most part, the cycle begins anew, and violence resumes. The honeymoon phase strengthens the emotional bond and dependency of the victim on the aggressor. This pattern of intermittent reinforcement makes it more challenging for the victim to leave the relationship.

It is important to understand that this cycle can last weeks, months, or even years, and as it progresses, the phases of reconciliation tend to shorten or disappear, while violence becomes more frequent and intense. Recognizing and understanding this cycle is crucial for intervention and support for victims, as well as for breaking the cycle of abuse.

The cycle of violence is essential for understanding how power dynamics and control are perpetuated in abusive relationships and why many victims find it difficult to escape.

The next section delves into the concept of gender-based violence during adolescence. This stage of life is particularly significant because it is a period of development and identity formation, making it a critical time for the prevention and recognition of violent behaviors.

5. Gender-based violence in adolescence

Adolescence is a transitional period between childhood and adulthood, characterized by significant physical, emotional, and social changes. During this stage, young individuals begin to establish deeper emotional relationships and experiment with their sexual and gender identities. However, it is also a time when they may be particularly vulnerable to the dynamics of power and control that underlie gender violence.

Gender violence in adolescence manifests in romantic and friendship relationships and can take forms similar to those observed in adult relationships, including physical, psychological, sexual, and economic violence. Nevertheless, there are specific characteristics of this stage that warrant detailed analysis.

5.1. Social and affective relationships in adolescence: Group belonging

During adolescence, the need for belonging and acceptance within a social group becomes crucial. Adolescents seek to establish their identity and belong to a peer group, which often influences their behavior and how they relate to others. This desire for belonging can have a significant impact on affective relationships, as young

individuals may be willing to tolerate abusive behaviors or adopt violent behaviors to maintain their social status or to avoid exclusion from the group.

For example, in some contexts, peer pressure can lead an adolescent to accept controlling or jealous behaviors from their partner as a test of love or commitment. These dynamics are particularly dangerous because they normalize violence and reinforce harmful gender stereotypes, such as the idea that jealousy is a manifestation of true love [25].

The influence of the group can exert pressure to conform to certain gender roles, which in turn perpetuates inequality and abuse. Adolescents may feel they must act in certain ways to meet the expectations of their peers, which can include the use of violence or the acceptance of violence in their relationships. Therefore, group belonging plays a dual role: it can be a protective factor when the group's values are positive and promote mutual respect, but it can also be a risk factor when violent and sexist behaviors are reinforced [26].

5.2. Learning violence in adolescence

Learning of violence during adolescence is a complex process influenced by multiple factors, including family, school environment, media, and society in general. During this stage, adolescents observe and imitate the behaviors of adults and peers, which can include violent and sexist attitudes.

One of the main channels through which adolescents learn violent behaviors is the family environment. If an adolescent grows up in a household where violence is common, they are likely to internalize these behaviors as normal and replicate them in their own relationships. For instance, an adolescent who witnesses violence between their parents may come to believe that it is acceptable to use force or control to resolve conflicts in their romantic relationships [27].

The school environment also plays a fundamental role in the learning of violence. The dynamics of power and control that develop among adolescents at school, such as bullying, can be precursors to gender violence in future relationships. Young people who are aggressors in the school context may transfer these behaviors to their romantic relationships, while victims of bullying may be more vulnerable to accepting abusive behaviors in their relationships [28].

Media and social networks have a notable influence on the learning of violence. Through exposure to violent, sexist content or narratives that glorify domination and control, adolescents may develop a distorted perception of what a healthy relationship looks like. Social networks, in particular, can, reinforce gender violence by providing platforms where harassment and control can be exercised continuously and on a large scale [29].

Authors like Bandura propose that violent behavior is learned through observation and imitation of models, which applies to gender violence. In social networks, adolescents may be exposed to violent or sexist behaviors, normalizing them or even viewing them as acceptable. Gender violence, as it is modeled and observed in their environment, including media and networks, can be replicated in their own relationships [30]. Similarly, it is posited that networks can act as models of behavior where adolescents learn gender roles and power dynamics, perpetuating sexist or

violent attitudes. Influencers, celebrities, and other users can have a significant impact on the beliefs and behaviors of young people.

Discourses surrounding male power, control over partners, and the sexualization of women can be reinforced through violent or degrading content on social media. In this sense, González delineates that harassment based on gender identity and sexual orientation is common in online environments, especially among adolescents. Social networks provide a setting where cyberbullying can manifest in the form of misogynistic comments, threats of violence, and controlling attitudes, contributing to the learning of gender violence [31].

The role of digital platforms is truly noteworthy. The report "Teen Dating Violence and Abuse, 2010–2014" analyzes the prevalence of violence in adolescent relationships, including exposure to psychological violence and control through social networks. It indicates that one in three adolescents has experienced some form of violence in their relationships, with many of these experiences being mediated or facilitated by digital platforms. Social networks enable forms of surveillance, control, and abuse, such as constantly checking profiles, demanding passwords, or controlling communication with other friends. This type of behavior can become normalized among adolescents if not intervened upon.

Cotterell [32] analyzes how social networks have assumed a central role in the socialization of adolescents, particularly in the construction of their identity and power relationships based on gender, perpetuating gender stereotypes and facilitating symbolic violence. Similarly, the study conducted by Muñiz-Rivas examines how adolescents internalize violent gender roles through various social mechanisms, including new technologies [33]. Through exposure to violent content and reinforcement of stereotypes on social networks, adolescents may come to see gender violence as acceptable or even normal. This idea is reinforced by studies such as Subirats [34], which analyzes the processes of gender socialization and how ideas about romantic love can perpetuate gender violence, especially among adolescents. It argues that social networks and media reinforce these traditional gender roles, leading to the acceptance of violent or unequal relationships.

On the other hand, authors Ortega et al. study cyberbullying and its relation to gender violence online. In their studies, they observe how cyberbullying among adolescents is linked to controlling and dominating behaviors that replicate dynamics of gender violence [35]. The report from the Youth Institute reveals concerning data on the increase of gender violence among adolescents in Spain, highlighting the role of social networks as mediums for harassment, dissemination of non-consensual sexual content, and as tools for exercising control and domination in relationships [36].

We can determine that social learning is key in this process, and the continuous exposure to violent or sexist attitudes and behaviors in networks can normalize gender violence among adolescents.

5.3. Indicators of violence

Identifying indicators of violence in adolescence is fundamental for prevention and early intervention. Often, the signs that a teenage relationship is violent can be

subtle and difficult to detect, both for the young individuals involved and for the adults around them. However, certain behaviors and patterns can serve as warning signs.

López-Cepero et al. [37], developed the "Questionnaire of Violence among Boyfriends," which identifies the following indicators of gender violence:

- Control over the partner: Controlling activities, friendships, clothing, and even the use of social media by the partner is one of the primary indicators. This presents itself as a way to exert dominance or power over the other person.
- Psychological violence: The use of insults, threats, or constant humiliations is another sign of gender violence. Although it often leaves no physical marks, its emotional effects are profound. Authors like Campbell have studied the consequences on physical and mental health due to partner violence, which includes effects on adolescents. Their work is essential for understanding the long-term risks of gender violence [38].
- Excessive and/or retrospective jealousy: The presence of excessive jealousy can lead to unfounded accusations of infidelity or demands for constant explanations regarding the partner's social life.
- Physical violence: Although it is not always present in the early stages, it can escalate from more subtle forms of control and psychological abuse to physical aggression.
- Social isolation: An aggressor may attempt to isolate their teenage partner from friends and family, making the person feel emotionally and socially dependent on him/her.
- Victim-blaming: The aggressor justifies their violent behavior by blaming the victim, indicating that she "provokes" the assaults through her behavior or appearance.
- Decreased self-esteem: Adolescents who experience gender violence often show low self-esteem, feeling increasingly insecure and dependent on their partner.
- Normalization of violence: Many adolescents view control or jealousy as a form of love, which complicates the identification of violence as such [39].

As indicated, gender violence in adolescence is a phenomenon influenced by individual, family, and social factors. The dynamics of power and control, along with the normalization of certain abusive behaviors, lead many adolescents not to identify abuse in their relationships. The studies of the mentioned authors are essential for understanding this phenomenon and designing effective interventions to prevent it.

5.4. The romantic myth

The romantic myth in adolescence and its relationship with gender-based violence is a topic that has been addressed by several authors in recent decades. These beliefs, related to idealized and passionate love, significantly influence the dynamics of youth romantic relationships.

The romantic myth refers to a set of idealized beliefs about love, typically based on the idea that love is the solution to all problems, that it is eternal, unconditional, and must involve sacrifice. During adolescence, these beliefs can create unrealistic expectations about romantic relationships, fostering emotional dependence and control. Some authors have pointed out that these myths contribute to the creation of

a "romantic script" that reinforces gender stereotypes and constitutes a risk factor for gender-based violence. These myths perpetuate unequal roles between men and women, where control and possession are interpreted as signs of love [40].

Regarding the relationship between this concept and gender-based violence, it is important to note that gender-based violence, particularly in youth relationships, is often rooted in beliefs about romantic love. Bengoechea have researched how adolescents internalize these beliefs, reproducing attitudes of control, jealousy, and possession that are justified under the guise of love [41].

In this context, the Association of Men for Gender Equality (AHIGE) emphasizes that the construction of masculinity based on domination and control over women is reinforced by romantic myths, which can lead to violence. Furthermore, psychologist, in her studies on romantic love and gender-based violence, emphasizes that adolescents tend to normalize abusive behaviors if these are framed within a romantic narrative [42].

Several studies have focused on analyzing how romantic myths relate to gender-based violence in adolescence. One such study by Rodríguez-Menéndez and Cuenca-Piqueras [43] analyzes how beliefs about romantic love contribute to the construction of unequal relationships and how these beliefs are linked to controlling behaviors and violence in young couples. Bengoechea explore the relationship between the normalization of violence in youth relationships and the influence of romantic myths on adolescents, highlighting the importance of affective-sexual education in preventing gender-based violence [44]. Herrera [42] provides an analysis of how adolescents reproduce the myths of romantic love and how this contributes to violence within romantic relationships, emphasizing the need to deconstruct these myths through education for equality.

In addition, De Miguel [44] reflects on romantic myths from a feminist perspective, highlighting their role in the reproduction of symbolic and real violence in intimate relationships, especially among youth. Meanwhile, Ferrer et al. [45] present an empirical analysis of the attitudes and beliefs of adolescents regarding violence in intimate relationships and the role that romantic myths play in the perpetuation of these behaviors.

The romantic myth is deeply ingrained in popular culture and adolescent expectations, playing a crucial role in how young people interpret romantic relationships. This set of idealized beliefs about love not only reinforces gender stereotypes but also creates a fertile ground for the emergence of gender-based violence. The cited authors have explored how education for equality and the demystification of romantic love are essential to prevent this violence [46,47]. For instance, adolescents may believe it is normal for their partner to want to control whom they talk to or where they go, interpreting this as a sign of love and concern. Similarly, they may view dramatic conflicts and reconciliations as a natural part of a passionate relationship, failing to recognize that these cycles of violence and reconciliation are, in fact, indicators of an abusive relationship.

The romantic myth is also reinforced through media and popular culture, which often glorify intense and conflict-ridden relationships as the ideal of love. Movies, television shows, and songs that present control, jealousy, and suffering as inevitable

components of love contribute to young people internalizing these behaviors as normal or even desirable.

Demystifying these beliefs is essential for preventing gender-based violence in adolescence. It is necessary to educate young people about what a healthy relationship truly entails—based on mutual respect, trust, and equality—and to help them recognize the signs of an abusive relationship before these harmful behaviors become normalized.

6. Risk factors in adolescence

This section explores the variables that may predispose adolescents to participate in, or be victims of, gender-based violence. These risk factors are numerous and can interact with each other, increasing the likelihood that violence will manifest in adolescent relationships.

The risk factors for gender-based violence in adolescence are multifaceted and encompass psychological, familial, social, and cultural aspects. These factors can predispose adolescents to experience or perpetrate violence in their romantic relationships. Below are the main risk factors detailed [48,49].

6.1. Individual factors

- Low self-esteem: Adolescents with diminished self-esteem are more vulnerable to tolerating abusive situations in their relationships, as they do not feel deserving of respect or equality.
- Emotional dependency: Individuals with a high need for affection or validation from their partner may justify control, jealousy, and possessiveness, increasing the risk of suffering or perpetrating violence.
- Beliefs in romantic myths: As previously mentioned, adolescents who believe in idealized romantic love may view abusive behaviors as "tests of love" and normalize violence.
- History of violence: Being a victim of abuse in childhood or witnessing violence among parents can heighten the risk of reproducing such behaviors in adolescence.
- Impulsivity and low frustration tolerance: Adolescents who struggle to manage their emotions may resort to violence as a means of controlling or expressing anger or jealousy.

6.2. Relational factors

- Unbalanced romantic relationships: When a relationship is based on control, possessiveness, or jealousy, the likelihood of gender-based violence increases. A lack of equality and mutual respect is a strong predictor of abuse.
- Economic or emotional dependency: If one partner is economically or emotionally dependent on the other, they may be more vulnerable to experiencing violence as they may feel unable to end the relationship.
- Excessive jealousy and control: Relationships characterized by controlling behaviors, phone monitoring, social isolation, and activity restriction are strong indicators of the risk of gender-based violence.

6.3. Familial factors

- Exposure to domestic violence: Growing up in an environment where violence is present between parents or in other close relationships reinforces the notion that violence is an acceptable way to resolve conflicts or maintain power in a partnership.
- Lack of communication and family support: Adolescents who do not have close or trusting relationships with their parents or relatives may lack emotional resources or guidance to recognize and prevent abusive behaviors in their relationships.
- Traditional gender role models: Families that reinforce rigid gender stereotypes, such as female submission and male dominance, promote unequal behaviors that can lead to violence.

6.4. Social and cultural factors

- Gender stereotypes and traditional roles: The belief that men should be dominant and women submissive can foster dynamics of power and control that lead to physical, emotional, or psychological abuse.
- Normalization of violence: Adolescents growing up in environments where violence is seen as a natural response to conflicts or as a form of affection may accept such behaviors in their own relationships.
- Peer group influence: The influence of friends is significant during adolescence. If the peer group accepts or promotes controlling or violent behaviors, adolescents are more likely to imitate these actions.
- Media representation: The portrayal of romantic relationships in movies, series, and music that romanticize control, jealousy, or suffering as tests of love can negatively influence adolescents' perceptions of what constitutes a healthy relationship.

6.5. Educational and socioeconomic factors

- Lack of affective-sexual education: The absence of educational programs addressing healthy relationships, gender equality, and emotional management can leave adolescents without the necessary tools to identify and prevent gender-based violence [50,51].
- Socioeconomic inequality: Situations of economic inequality or lack of opportunities can generate stress and frustration, which in some cases lead to power dynamics or control in relationships [52].
- Disadvantaged environments: Living in neighborhoods with high crime rates or poverty may expose adolescents to violent behavior models or environments where violence is a common strategy for problem-solving.

6.6. Technological factors

- Cyberbullying and digital control: The use of social media and messaging applications has created new forms of control and abuse in adolescent relationships. Monitoring a partner's phone, demanding access to social media

accounts, or exercising constant surveillance are forms of violence that are amplified by technology.

6.7. Substance abuse

- Substance use: Excessive consumption of alcohol or drugs can increase the likelihood of violent behaviors, as it affects emotional control, inhibition, and judgment, potentially leading to gender-based violence.

After identifying numerous risk factors, we can consider that prevention requires a comprehensive approach that includes affective-sexual education, questioning traditional gender roles, strengthening adolescents' self-esteem, and promoting relationships based on respect and equality.

7. Prevention and response to gender-based violence in adolescence

The prevention and response to gender-based violence in adolescence have been the subject of analysis in multiple studies, highlighting the importance of early intervention to prevent the consolidation of patterns of abuse and violence. Adolescence is a crucial stage in the formation of identity and interpersonal relationships, making it essential to foster values of respect and equality in early romantic relationships [43]. According to Kotiuga et al. [53], adolescents are in a process of consolidating their self-concept and relationships, so the internalization of traditional gender roles can negatively influence their perception of what constitutes a healthy relationship.

One of the most prominent approaches for preventing gender-based violence at this stage is the implementation of educational programs in schools. According to Álvarez-García [54], Pérez y González educational programs aimed at adolescents should include activities that promote questioning gender stereotypes, fostering equality, and assertive communication in affective relationships [55,56]. These programs have proven effective in reducing the prevalence of sexist attitudes and tolerance towards violence in romantic relationships [45].

As noted by Peterson, another key aspect is the role of families. Family dynamics and the behavior models observed at home are determinants in shaping beliefs about gender roles. Violence within the family can become normalized for adolescents if there is no early and adequate intervention [57].

When gender-based violence is detected in adolescents, action must be swift and multidisciplinary. It is necessary for educational institutions, social services, and health professionals to work together to provide comprehensive support to victims. Intervention should include psychological support to help victims overcome trauma, as well as the implementation of legal measures in cases of severe violence [58].

Furthermore, as Huster and Longo points out, it is also necessary to work with adolescent aggressors to prevent recidivism and promote behavioral change [59]. Reeducation through anger management programs and the teaching of social skills can be effective in modifying violent behavior patterns [60].

Preventing and responding to gender-based violence in adolescence requires a comprehensive strategy involving educational institutions, families, and health and social services. Early intervention is essential to prevent the chronicity of violence in

romantic relationships and ensure that adolescents grow up in an environment of equality and respect.

Preventing gender-based violence in adolescence is a challenge that requires a holistic approach, involving various stakeholders and sectors of society, such as schools, families, social services, the media, and technology. The following details how each of these areas can contribute to preventing this issue and how awareness campaigns play a crucial role in raising consciousness and education.

7.1. School environment

The school environment is one of the main settings where attitudes and behaviors related to gender-based violence in adolescents can be prevented. Educational programs are essential for addressing this issue. It is crucial to integrate content promoting gender equality and peaceful conflict resolution within school curricula. Key measures include initiatives like workshops on healthy relationships, talks with specialists, and the establishment of protocols to address instances of violence [54].

In addition, training teachers and educational staff is vital so they can recognize early signs of violence and respond effectively [43]. This training encompasses identifying controlling behaviors in adolescent relationships and recognizing sexist attitudes that may be precursors to more severe violence.

Schools are pivotal in addressing GBV. Programs such as "Safe Dates" in the U.S. demonstrate how integrating gender equality education within curricula can reduce tolerance toward violence and sexist attitudes among students [61]. Workshops on healthy relationships, teacher training, and clear protocols for addressing violence are effective measures. Moreover, studies like that of Ramírez et al. [62] document the success of Latin American initiatives such as "Género y Juventud," which reduced harmful attitudes and improved conflict resolution among adolescents.

7.2. Family environment

The family plays a fundamental role in the prevention of gender-based violence. Behavioral patterns observed at home significantly influence how adolescents build their relationships. The families should educate towards equality and avoid perpetuating traditional gender stereotypes that encourage roles of domination or submission [57]. To this end, it is essential for parents to be actively involved in their children's emotional education, fostering empathy, respect, and equality in their interpersonal relationships.

Training programs aimed at parents can be valuable for teaching them how to recognize signs of violence in their adolescent children's relationships and how to respond to potential risk situations [45].

Family dynamics significantly influence adolescent relationship patterns. Research shows that exposure to domestic violence increases the likelihood of normalizing abusive behaviors unless addressed through interventions like the "Parent-Child Interaction Therapy" (PCIT), which promotes healthier family relationships [63]. Parent-focused workshops are also valuable, as seen in the Canadian initiative "Respectful Relationships," which educates families about identifying early warning signs of GBV [64].

7.3. Social environment

In the social sphere, community networks, associations, and collectives also play a crucial role in preventing gender-based violence. According to Varela et al. [58], community activities that promote peaceful coexistence and gender equality—such as discussion forums, co-ed sports, and awareness workshops—are essential for eradicating sexist attitudes that may lead to violence.

Coordinated efforts between social services and schools are vital to identify at-risk situations and provide support to adolescents who are victims or at risk of gender-based violence. Additionally, feminist associations and civil society organizations can offer educational resources and guidance for adolescents and their families.

Community networks and organizations play a crucial role in fostering equality and addressing GBV. Varela et al. [58] describe successful examples of community engagement, such as co-ed sports leagues and discussion forums, which help dismantle stereotypes and promote healthier social norms. Collaborative efforts, such as "Multi-Agency Risk Assessment Conferences" (MARACs) in the UK, have shown significant reductions in recidivism among young perpetrators of violence through coordinated responses [65].

7.4. Media

The media has a powerful influence on shaping perceptions of gender-based violence. The way relationships and gender roles are portrayed on television, in movies, and on social media directly impacts how adolescents understand violence within their own relationships.

It is essential that media outlets avoid perpetuating gender stereotypes and instead promote narratives that highlight equality, respect, and the condemnation of gender-based violence. Media should serve as allies in raising societal awareness by spreading campaigns that encourage healthy relationships and openly denounce violence.

Media representations of gender roles deeply influence adolescents' perceptions of relationships. Campaigns like "No es Amor" in Spain challenge toxic narratives by educating youth about possessive and abusive behaviors. Studies underscore the role of media in disseminating positive role models and raising awareness about GBV, which has been effective in reshaping public discourse [66].

7.5. Technology and social media

Technology, especially social media, can serve both as a risk factor and as a tool for preventing gender-based violence. In terms of risk, cyberbullying and control through digital platforms are forms of violence increasingly affecting adolescents [60]. Educational institutions and families need to teach young people how to recognize and report these forms of abuse.

On the other hand, technology can also be an ally in prevention through the dissemination of educational content and awareness campaigns on social media. As Vega et al. [67] point out, there is a need to develop applications and platforms that provide support and guidance resources for young victims of gender-based violence.

While social media can amplify GBV through cyberbullying and digital abuse, it also offers opportunities for prevention. Applications like "Línea de Ayuda

Adolescente" provide discreet support for victims, while campaigns on platforms like Instagram educate about identifying toxic behaviors [67]. These digital tools have been effective in reaching broader audiences and fostering awareness.

7.6. Awareness campaigns

Awareness campaigns are essential tools for preventing gender-based violence among adolescents. These campaigns often aim to bring visibility to the issue, dismantle myths around romantic love, and promote equal relationships based on mutual respect.

One prominent campaign in Spain is "No es Amor" ("It's Not Love"), promoted by the Institute for Women, which seeks to dispel misconceptions about possessive love and educate adolescents on warning signs in relationships. Another key campaign is "Quiéreme Bien" ("Love Me Well"), disseminated on social media, targeting a young audience with messages about respect and equality in relationships.

Preventing gender-based violence in adolescence requires a multi-sectoral approach that includes educational, family, and social settings, with support from media and technology. Awareness campaigns play a crucial role in educating adolescents, encouraging relationships grounded in respect and equality. The collaboration of all social actors is vital for eradicating this form of violence and ensuring a safe and healthy environment for future generations.

Awareness campaigns are powerful tools in preventing GBV. The Spanish campaign "Quiéreme Bien" effectively uses social media to reach adolescents, promoting messages about equality and healthy relationships. Evidence from interventions in Australia and Canada shows that sustained awareness efforts can significantly reduce incidents of GBV among youth populations [68].

8. Consequences of gender-based violence on the victim and penalties for the aggressor

Gender-based violence during adolescence can have profound and lasting consequences for both victims and aggressors. This stage is crucial for emotional and psychological development; therefore, the impact of such violence can affect multiple areas of their lives, with implications that may extend into adulthood. The repercussions may manifest in psychological, social, academic, and physical realms, as well as influence the development of future interpersonal relationships.

8.1. Consequences for adolescent victims

Psychological and relational consequences: Adolescent victims of gender-based violence often experience significant psychological impacts. Common effects include anxiety, depression, low self-esteem, and symptoms of post-traumatic stress disorder. Repeated physical and emotional violence can lead the victim to develop a state of learned helplessness, where they feel unable to escape the situation. Additionally, according to Ferrer et al. [45], adolescent girls may experience feelings of shame, guilt, and fear, which inhibit them from reporting the situation or seeking help.

During adolescence, individuals are in the process of constructing their identity and developing emotional relationships. Exposure to an abusive relationship can

distort their perception of what constitutes a healthy relationship, impacting their ability to establish healthy emotional bonds in the future [57]. This can lead to the repetition of abusive relationship patterns in adulthood.

Educational consequences: Gender-based violence can severely impact the victim's academic performance. Emotional trauma and stress interfere with their ability to concentrate and learn. In some cases, victims may resort to social isolation or absenteeism, which also affects their relationships with peers and teachers [43]. Furthermore, there may be social disconnection and an increasing mistrust towards others.

Physical consequences: Adolescent victims of gender-based violence may suffer physical injuries as a result of abuse, ranging from bruises to more serious damage [58]. In cases of sexual abuse, victims may also experience reproductive health issues, sexually transmitted infections, and unintended pregnancies.

Mental health consequences: Adolescent girls who suffer from gender-based violence are at higher risk of developing long-term mental health disorders, such as chronic depression, anxiety disorders, and tendencies toward self-harming or suicidal behaviors [53]. Exposure to violence at such a sensitive stage can have a persistent impact on emotional well-being.

8.2. Consequences for the adolescent aggressor psychological consequences

Adolescent perpetrators of gender-based violence are often witnesses to or victims of violence within their family or social environments [54]. Without proper intervention, there is a high risk that these patterns of violent behavior will continue in their adult relationships. Violence becomes an acceptable way to resolve conflicts or assert control over a partner.

Aggressors often lack emotional skills such as empathy and self-control, exacerbating their violent behavior [60]. These individuals tend to experience difficulties forming healthy and respectful relationships during adolescence and adulthood. Moreover, their aggressive behavior can lead to social isolation or rejection, reinforcing hostility towards others.

Educational consequences: The violent behavior of aggressors can result in academic problems, including school expulsion or declining academic performance. As noted by Rodríguez-Menéndez and Cuenca, aggressors often display a lack of respect for rules and authority, leading to disciplinary or even legal consequences. In severe cases, they may face charges and judicial consequences, marking their legal record from an early age [43].

Mental health consequences: Aggressors may also experience mental health issues, though in a manner distinct from victims. Impulsivity, uncontrolled anger, and an inability to manage emotions effectively can lead to disorders such as depression, anxiety, and anger management issues [45]. In some cases, aggressors may have been victims of violence themselves, adding an additional layer of emotional complexity to their behavior.

Without appropriate treatment, adolescent aggressors are likely to replicate violent behaviors in future relationships. According to Varela et al. [58] the lack of

reeducation in emotional and social skills can lead to repeated patterns of domination and abuse in their adult relationships, perpetuating an intergenerational cycle of violence.

8.3. Intervention and prevention

It is crucial to intervene with both victims and aggressors to break the cycle of adolescent gender-based violence. Early and appropriate intervention in both cases can help mitigate long-term consequences. Reeducation programs for aggressors, psychological support for victims, and social awareness of the issue are essential measures [69].

Victims need psychological support to overcome trauma and rebuild their self-esteem, while aggressors require intervention to learn self-control, empathy, and peaceful conflict resolution skills. Emotional and gender equality education from an early age is also key to preventing gender-based violence before it manifests.

Adolescent gender-based violence has devastating consequences for both victims and aggressors. In both cases, the effects can extend throughout life, affecting mental health, personal relationships, and emotional development. Early intervention and gender equality education are key tools to break the cycle of violence and ensure a healthier and more equitable future for both [53,56,70].

8.4. Penalties for adolescent perpetrators

Penalties for adolescent perpetrators of gender-based violence in Spain are regulated by Organic Law 5/2000 on the Criminal Responsibility of Minors, which sets the framework for judicial intervention with minors aged 14 to 17. Adolescents can be prosecuted for gender-based violence crimes, but the sanctions differ from those imposed on adults, as the system is more focused on rehabilitation than punishment.

The main sanctions that can be imposed on a minor offender are as follows:

8.4.1. Detention in a juvenile center

Different types of detention exist: Closed detention; the minor is deprived of liberty and placed in a specialized center under strict conditions, which include educational and training activities. The duration varies according to the severity of the offense but can last up to 6 years; Semi-open detention; this combines confinement within the center with the possibility of supervised external activities; Therapeutic detention; applied in cases where the minor exhibits psychological, behavioral, or addiction issues and requires specialized treatment in a controlled setting.

8.4.2. Supervised freedom

This measure can last up to 5 years and entails continuous supervision of the minor's behavior. During this period, the offender is subject to certain restrictions, such as the prohibition of approaching the victim, and is required to follow educational or re-education programs on gender equality and peaceful conflict resolution.

8.4.3. Community service

The court may require the minor to perform unpaid community service. These tasks are designed to educate the offender on values of respect and equality. The

maximum duration of this measure is 200 h.

8.4.4. Prohibition of contact and communication

The offender may be sentenced to a prohibition on approaching or communicating with the victim by any means (phone, social media, etc.), including restrictions on approaching their residence or school. This measure is typically applied to protect the victim and can last for several years.

8.4.5. Educational or reintegration programs

The judge may order the minor to participate in educational or therapeutic programs aimed at re-educating and raising awareness about gender-based violence. The objective is to change the minor's sexist and violent attitudes, teaching them to manage emotions and behaviors in a non-violent manner.

8.4.6. Fines or compensation

If deemed appropriate by the judge, the minor may be required to pay a fine or provide compensation for damages caused to the victim, although this depends on the minor's and their family's financial capacity.

8.4.7. Judicial warning or admonition

In less severe cases, the judge may opt for a formal warning, informing the minor of the consequences of their behavior and urging them to change their attitude.

8.4.8. Complementary measures

In addition to the sanctions mentioned, courts may impose other measures such as participation in psychological therapy, anger management courses, or gender equality programs to prevent recidivism.

Various factors may influence the imposition of penalties on the offender, such as the gravity of the offense, the degree of violence, the harm caused to the victim, and the offender's personal circumstances, including family, psychological, and social background, or issues with addiction. For repeat offenders, penalties tend to be more severe.

The focus of juvenile law in Spain is primarily on the rehabilitation and reintegration of the juvenile offender, aiming to prevent such behavior from continuing into adulthood. However, given the notable increase in gender-based violence cases among adolescents, with increasingly violent incidents, many in society and among professionals advocate for a restructuring of this law to favor the victim and provide a more deterrent measure for offenders.

8.5. Resources for victims

In Spain, there are various resources available to provide protection and assistance to adolescent victims of gender-based violence, designed to offer emotional, legal, and psychological support while ensuring their safety. The main resources are outlined below:

8.5.1. Help and emergency hotlines

- Gender-based violence victim assistance hotline.

This free, confidential service operates 24/7, year-round, providing information on rights, support services, and protection measures for gender-based violence victims.

It leaves no trace on phone bills or call records, ensuring discretion. Assistance is available in 52 languages, with a special service for people with hearing or speech disabilities.

- ANAR Hotline: 900 20 20 10. This hotline is specifically aimed at adolescents and children who are victims of violence or at risk. It offers free, anonymous psychological, social, and legal assistance, available 24 hours a day, managed by the ANAR Foundation (Aid for Children and Adolescents at Risk).

8.5.2. Protection and security services

- Restraining orders and judicial protection. Victims of gender-based violence can request a restraining order prohibiting the offender from approaching or contacting them. This measure is managed by the courts and the police. An integrated protection order may also be granted, which includes security, judicial, and social protection measures.
- Electronic monitoring bracelets. To ensure the victim's safety, offenders are sometimes required to wear electronic bracelets that alert the police if they approach the victim, thereby violating the restraining order.
- VioGén system. This comprehensive tracking system for gender-based violence cases coordinates actions among law enforcement, social services, and judicial authorities. The VioGén system assesses the risk to the victim and adjusts protection measures based on the aggressor's threat level.

8.5.3. Psychological and social support

- Integrated women's support centers. Managed by regional and local governments, these centers offer specialized psychological, legal, and social support for women and adolescent victims of gender-based violence. They provide both individual and group support services, aiding victims and their families.
- Specialized psychological support programs. Many autonomous communities offer free psychological intervention programs specifically for adolescent victims of gender-based violence, managed by mental health and social welfare services.
- Individual therapy. Provides emotional support to help adolescents overcome trauma and restore self-esteem.
- Group therapy. Offers victims the opportunity to share experiences with others in similar situations, helping them feel less alone.

8.5.4. Shelters and supervised housing

For victims who need to leave home for safety reasons, shelters and supervised housing provide temporary accommodation, protection, and emotional support. These resources are managed by the social services of regional governments, allowing adolescent victims of gender-based violence and their children, if they have any, to live in a secure environment while receiving professional assistance.

8.5.5. Free legal assistance

Adolescent victims of gender-based violence have the right to free legal assistance, regardless of their economic situation. Specialized gender-based violence attorneys guide them through the judicial process, from filing complaints to seeking protection measures or claiming compensation.

8.5.6. Family meeting points

These centers are available to ensure that adolescent victims of gender-based violence can maintain contact with their families in a safe and controlled environment, if necessary. Family meeting points are neutral spaces where victims can meet with family members under professional supervision when there is a risk in family interactions.

8.5.7. Education and awareness programs

- Preventive educational programs. Educational institutions and non-governmental organizations conduct gender-based violence prevention programs aimed at adolescents. These programs address gender equality, peaceful conflict resolution, and the identification of abusive behaviors. Workshops like "Educating for Equality" or "This Isn't Love" aim to raise adolescents' awareness of gender-based violence indicators and promote healthy relationships [53,56,71].
- Educational materials and social media campaigns. Platforms and websites like the Women's Institute or the National Youth Institute (INJUVE) provide educational resources on adolescent gender-based violence. Social media campaigns also raise awareness among adolescents on this topic, promoting respect and equality in romantic relationships.

8.5.8. Organizations and NGOs providing support

- ANAR foundation. In addition to its hotline, the foundation offers protection and emotional support programs for minors at risk and gender-based violence victims. It provides assistance with filing complaints and psychological support.
- Women's foundation. This foundation works on gender-based violence prevention and awareness, offering support programs for adolescent victims and their families, as well as educational resources.
- Save the children. Save the Children provides assistance to at-risk minors, including victims of gender-based violence, through educational and social programs, as well as direct psychological and legal support actions.

8.5.9. Emergency mobile applications

- AlertCops. A Ministry of the Interior application that allows gender-based violence victims to discreetly alert security forces in emergencies by sending their real-time location and a distress message.
- Libres. This app, promoted by the Ministry of Equality, offers resources, guidance, and advice for women, including adolescents, suffering from gender-based violence. It also provides access to help hotlines and advice on seeking protection measures.

9. Conclusion

Gender-based violence during adolescence is a deeply entrenched societal issue, with devastating consequences for both victims and perpetrators. This study has enabled an exploration of the various factors contributing to its emergence, the multiple forms of violence that manifest during this period, and the severe repercussions on physical, psychological, emotional, and social levels.

One of the key conclusions is that adolescence represents a period of critical vulnerability, where young people are in the process of forming their identities and experiencing their first intimate relationships. During this stage, gender stereotypes, the myth of romantic love, and observed behavioral models within family, school, and media play a fundamental role in normalizing violent behaviors. Consequently, affective-sexual education and the promotion of relationships based on respect and equality emerge as essential factors for preventing gender-based violence from early ages. This study contributes to existing knowledge by emphasizing the intersection of cultural, emotional, and educational influences during adolescence, providing a nuanced understanding of how gender-based violence originates and perpetuates within this vulnerable period.

Furthermore, this study underscores the importance of early identification of signs of violence within adolescent relationships. Control, jealousy, emotional manipulation, and cyberbullying are less visible but equally destructive forms of violence that can escalate into more severe aggression if left unaddressed. In this regard, strengthening support networks at both familial and institutional levels is critical for providing adolescents with the tools needed to recognize and reject abusive behaviors.

The study also highlights the need for a multidisciplinary intervention involving family, schools, social services, and the judicial system. Re-educating adolescent offenders is crucial to prevent the perpetuation of violence in future adult relationships, while emotional and psychological support for victims is indispensable for their recovery and the rebuilding of self-esteem.

Future work stemming from this study could involve the development and testing of specific intervention programs tailored to adolescent experiences, integrating insights from this research to refine preventive strategies and education models. Additionally, longitudinal studies could track the long-term impacts of early interventions, deepening our understanding of how early prevention shapes relational dynamics into adulthood.

Finally, it is imperative to continue working on awareness campaigns and to consider legislative revisions that protect adolescents from gender-based violence. These measures should ensure victims' safety, provide accessible and effective resources, and apply sanctions that, beyond penalization, seek the reintegration of offenders.

Gender-based violence in adolescence is an alarming reality that demands a comprehensive response. By identifying specific gaps in current interventions and exploring new avenues for action, this study not only sheds light on the complexities of this issue but also lays the groundwork for practical, evidence-based solutions. Only through education, social awareness, and a preventive and restorative approach from early ages will it be possible to eradicate this phenomenon and foster healthy, respectful relationships grounded in equality.

Conflict of interest: The authors declare no conflict of interest.

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Brief Report

Mortality in neonate bats infested by ectoparasite bugs in India; humans are at risk too

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Abstract: Human bed-bugs are well known and are found almost all over the world. Many types of bugs that infest various species of bats (Chiroptera: Mammalia) are found in different geographical areas or ecosystems, feeding on their blood. These small bugs, which are external parasitic insects, belong to the family Cimicidae of the order Hemiptera of the class Insecta of the phylum Arthropoda of the animal kingdom. Their bites can cause negative health effects in humans such as skin reactions, anemia, insomnia, anxiety, and panic attacks. Although their bites and bloodsucking do not kill any host. In general, bat-bugs infest adult and old bats. But, recently in Udaipur, Rajasthan, India, six neonates or neonate bats of small Asiatic yellow bats (*Scotophilus kuhlii*) were also found infested with bat-bugs ectoparasites belonging to the genus *Cimex* Linnaeus, 1758 (*Cimex pattoni*). Such a rare and unique instance has never been observed and reported earlier from any geographical area in the world. Interestingly, out of these, three were also found dead (66.6%), two were in a dying state, and one was in a critical condition or struggling for survival. Due to our limitation, the exact cause of death in these infested bat neonates with bug parasites has not been investigated. In the present communication, details of this case have been focused on and also focus on how much people are at risk of infestation from these external parasitic bat-bugs.

Keywords: Asian yellow bats (*Scotophilus kuhlii*); neonate bats; bat-bugs; ectoparasite; health; humans; infestation; insects; India

1. Introduction

There are many species of tiny bugs found all over the world that are external parasitic insects of the family Cimicidae, belonging to the order Hemiptera of the class Insecta of the phylum Arthropoda of the animal kingdom [1]. In India, these insects are commonly known as “Khatmal” (in Hindi). However, maximum study and information about them is limited to human bed-bugs (*Cimex lectularius, C. lectularius, C. hemipterus, C. rotundatus, C. piloselus, C. pipistrale*, etc.). Generally, these ectoparasite bugs prefer to live in cracks and crevices, and they can survive in an unfavorable environment without food (blood) for many months or even years [2]. These nocturnal insects are also well adapted anatomically, morphologically, and physiologically, due to which they can survive for a long time even in adverse environments and have evolved excellent organs to suck the blood of not only human beings but also of various species of bats (Chiroptera: Mammalia) living in deserted ruins, abandoned buildings, caves, houses, and cracks and hollows of trees

around human settlements. Interestingly, they do not spare even the small cliff swallow (*Petrochelidon pyrrhonota*) which lives in mud nests under houses, buildings, and bridges [3,4]. These insects also infest birds and have been reported in birds like chickens, owls, and woodpeckers. These insects are also called bed-bugs, bat-bugs, swallow-bugs, and poultry-bugs depending on their host species. But all insects of different host species, be it human beings, bats, or birds, look almost similar in morphology or structure, and their behavior is also almost similar. Bat-bugs are very similar to bed-bugs and are so similar in appearance that they are often mistaken for bed-bugs. Therefore, a microscopic examination is required to correctly identify them. Interestingly, these bat-bugs can also bite humans and cause negative health effects such as skin reactions, anemia, insomnia, anxiety, and panic attacks in people [5–7]. In general, bat-bugs infest adult and old bats but not neonate bats. But, recently in Udaipur, Rajasthan, India, neonate bats of small Asiatic yellow bats (*Scotophilus kuhlii*) (**Figure 1a–d**) were also found infested with bat-bugs ectoparasites belonging to the genus *Cimex* Linnaeus, 1758 (*Cimex pattoni*) (**Figure 1d–f**). Such a rare and unique instance has never been observed and reported before from any geographical area in the world. Among these infested neonate bats, 66.66% are also found dead. In the present communication, details of this case have been discussed, and there is also a focus on how much people are at risk of infestation from these external parasitic bat-bugs.

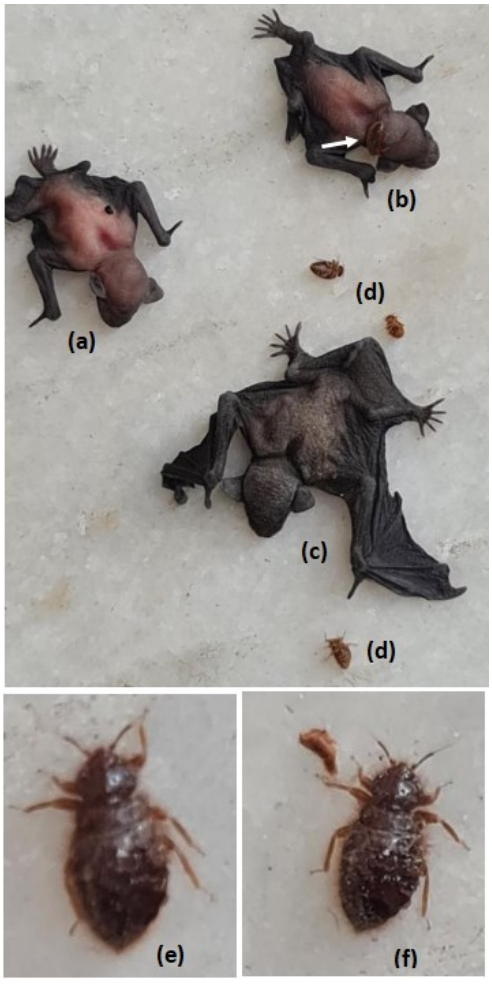

Figure 1. Baby or neonate bats infested with ectoparasite bugs.

One of these neonate bats has died **(a)**, while others infested with bugs are struggling to survive **(b,c)**. Some bugs **(d)** have been isolated from the baby bats **(c)**. Mature **(e)** and immature bugs **(f)** were recovered from the neonate bats **(b,c)**. Arrow indicates bug parasite sucking blood at dorsal side of neck region.

2. Mortality in infested neonate bats with ectoparasite bugs

Recently, during the rainy season (July, 2024), six small babies of small Asian yellow bats (*S. kuhlii*) were found lying under a cement pipe protruding from the roof of a house in Udaipur city of Rajasthan (India). Of these, three were found dead, two were in a dying state, and one was in a critical condition or struggling for survival. On closer inspection, 3-4 small bugs were found stuck on the dorsal surface of all these neonates or babies. When these bat-bugs were pressed lightly, blood oozed out of them. In fact, all these bat-bugs were full of blood. Surprisingly, when they were separated from the neonate bats with the help of a thin wooden stick, some of them quickly ran back towards these babies and stuck to their bodies again. There were some who fell upside down during separation. But in a short while, they immediately got back upright and ran towards these babies and stuck to them again. Such aggressive behavior of theirs was never seen and reported before. How do these insects or bat-bugs recognize their host, and how are they attracted towards them? But in the absence of research, it is not right to say so.

In the present study we found 66.66% mortality in baby bats infested with bugs. It is well known that blood sucking by bugs can cause mild to severe anemia depending on the parasitism or parasitaemia [8–11]. Parasitic bugs also suck the blood of neonate bats and develop anemia, which can cause mortality in them. However, we have not investigated the hemoglobin (Hb) level in any infested neonate bats to confirm the evidence of anemia in them. On the other hand, it is also possible that they die due to starvation. However, without any concrete evidence, it is difficult to say what was the exact cause of death in these newborns, and it is not clear yet. The truth is that we have suddenly come across this case, or this case has come to us by chance. In fact, due to our limitations, we have not investigated to find out the cause of postnatal death, so this can be a subject of further research.

In the world, various species of bat-bug ectoparasites derived from different bat host species have been well studied and reported from different geographical provinces [12,13]. In India, the first report on bat-bugs was reported in 1912 [14]. Subsequently, more than 15 more species of bat-bugs belonging to the family Cimicidae have been reported in different species of bats surviving in or around human habitations, which have been well reviewed [15–23]. From the states of Rajasthan and Gujarat of the country, five species of bat-bugs (*Cimex ueshimai, C. pattoni, Cacodmus bhati, Leptocimex hiregaudari, and Stricticimex namru*) from six species of bats (*Pipislrellus dormeri dormeri, Tophozous longimanus, Scotophilus heathi heathi, Taphozous kachhensis kachhensis, Rhinopoma microphylum microphyllum, and Tadarida aegyptiaca thomasi*) belonging to the Pteropidae family have also been reported [14,15]. Based on the literature, the current species of the ectoparasitic bug is *C. pattoni*, recovered from the pups of either *S. kuhlii* or *S. heathi heathi*. Though both species are small and have little difference in their

morphology, the habitats are quite different. However, the first species is more accurate and possible, as these small creatures also roost in hidden places (cracks, crevices, cemented pipes coming out of the roofs of houses, abandoned buildings, hollows of nearby trees, etc.) found in the vicinity of human habitation. The present neonate bats were also found in similar habitat or lying under a cement pipe coming out of the roof of a house. This species enters people's homes at night whenever it gets a chance. Which can also be a danger to humans. Because when these bats hide in houses, their bug parasitic insects also go to the houses along with them, which hide in the nearby cracks and bite the people of that house and suck their blood as soon as they get a chance. It is, generally, believed that the bite of these insects does not spread any infectious disease in humans. But human bed-bugs have been reported to be carriers of many pathogens [23–30]. Bed-bugs have also been found to be infected in nature with *Wuchereria bancrofti* and *Brugia malayi* (causes of filariasis)*, Trypanosoma cruzi, Brucella melitensis, Coxiella burnetii,* and Rickettsia, which causes exanthematous typhus [13,23–30]. However, more authentic or scientific studies are still needed to confirm whether these bat parasites can cause and spread any infectious disease in humans.

3. Significance

The death of neonate bats suffering from bug parasites can affect their survival and population. The reduction in their population can harm the environment. Because bats are a natural source of controlling the population of various pests that harm economically important plants and agricultural crops [31,32]. Bats also disperse the seeds of fruit trees, thereby strengthening the existing ecosystem [33–35]. Due to the social behavior of bats and their proximity to human populations, bat-bug parasites can also be spread to humans. Much research is still needed in India to understand bat-bug parasitism and the behavior of different species of bats inhabiting human habitations. However, the significance of this report is that this is the first time that dead neonate or immature bats have been found infested with bug parasites, which is rare and unique. This important finding also adds to or expands the existing knowledge about parasitism in bats.

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Short Report

First field and laboratory trial of VectorBac® WG around the airport zone of the capital city of Libreville, Gabon

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Abstract: Context/Purpose: The urban ecosystem of Akanda behind the airport of the capital city of Libreville in Gabon, harbors diverse and dense mosquito larval habitats and hotspots for malaria and arboviruses transmission. To effectively conduct vector control, it is imperative to adopt an integrated approach by adding biolarvicides to the toolbox. The main objective of this study is to evaluate the efficacy of a biolarvicide under laboratory and field conditions. **Methods:** In Gabon, this current pilot and preliminary study sought to test the efficacy of the biolarvicide VectorBac® Water dispersable Granule (WG) (VBG) during the rainy season period (March to May 2024) under field and laboratory conditions following the 2005 World Health Organisation protocol. **Results:** For the bioassay of VBG, in the laboratory, the required dose to kill 88% and 100% of the larvae in rearing cups was 0.001 g/mL and 0.01 g/mL respectively. Under field conditions, the percentage larval density reduction irrespective of the microhabitat type ranged from 90 to 100% and the mosquito larval density reduction between test and control groups in the field differed statistically (X^2=34; p = 0.026). **Conclusion:** The larvae from Akanda tested under field and laboratory conditions were very sensitive to the standard dose recommended by the manufacturer after 24 hrs post-treatment with VBG. This pilot study provides baseline information that is required to conduct a longitudinal study to evaluate the residual effect of VBG in different ecological settings in Gabon.

Keywords: *Aedes*; *Anopheles*; *Culex*; larva; VectorBac®; Akanda

1. Introduction

Malaria and arboviruses are transmitted by mosquitoes and these insect larvae have been identified in different microhabitats in urban areas [1,2] and in protected areas beside the city [3]. The control of mosquitoes in Gabon is being carried out using some strategies such as indoor residual spraying, use of insecticide treated bed nets and public hygiene (construction of urban drainage systems and regular emptying of waste bins). To effectively and sustainably tackle this important public health parasitic and arboviral diseases transmitted by mosquitoes, it is imperative to combine different antivectoral fight strategies alongside biolarvicides. Larviciding has been reported as possible control measure for malaria (*Anopheles gambiae*) and filariasis (*Culex quinquefasciatus*) vector control particularly in managing pyrethroid-resistance in African malaria vectors [4]. However, this approach has not yet been tested in Gabon especially in areas such as the airport area of Akanda that have already been reported to be densely infested with mosquito larvae.

2. Methodology

2.1. Study area

This study was conducted in the Zone of Akanda and its environs (**Figure 1**). The area is characterized by high construction works such as the construction of a new airport road to ease traffic and this activity expands mosquito breeding grounds. The equatorial rainforest of Gabon favors the proliferation of several species of mosquitoes and some have already been identified to be vectors of arboviruses [5].

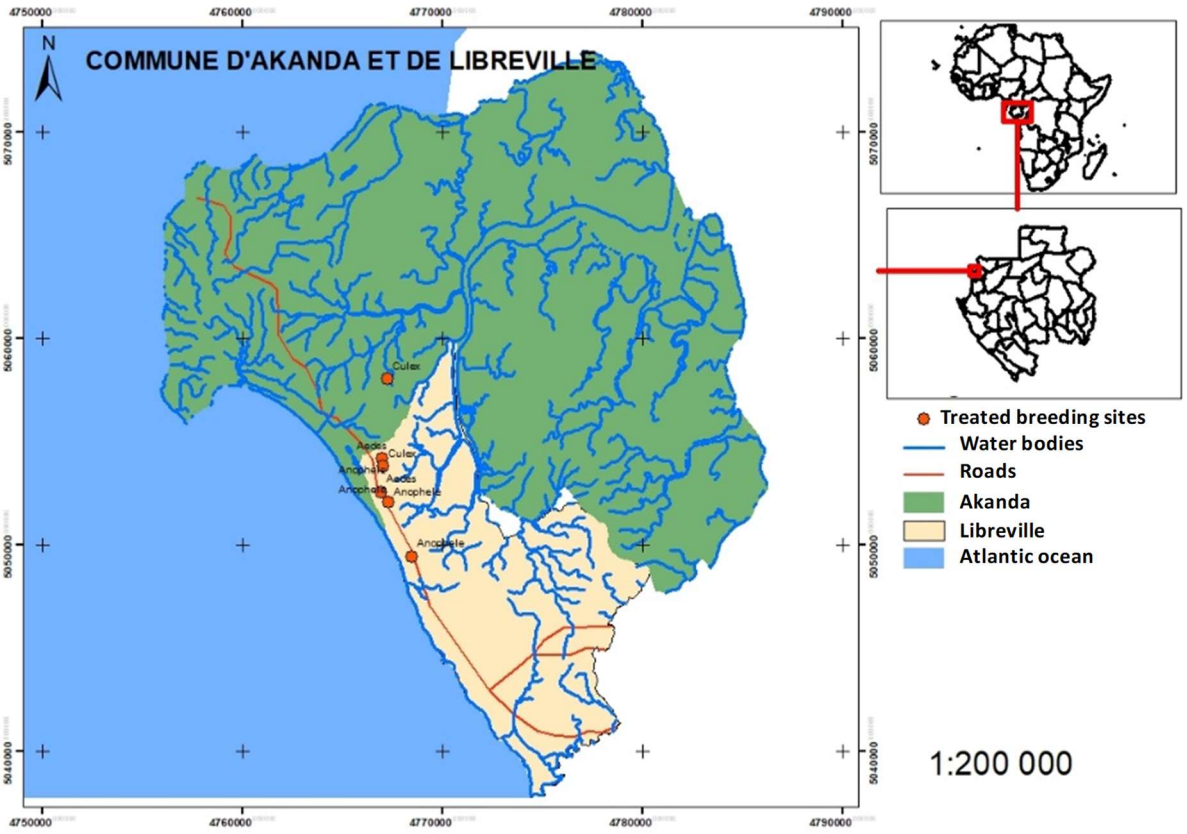

Figure 1. Map of breeding sites of the three mosquito genera treated with VBG.

2.2. Mosquito collection

The field and laboratory testing of VBG was conducted as stated in WHO [6]. All three instar (L3) larvae collected and belonging to the genera *Anopheles*, *Aedes* and *Culex* were used to test for the larviciding effect of VBG in the laboratoire d'ecologie des maladies transmissibles (LEMAT) (**Figure 2**). In the field, different microhabitats harboring the larvae of the three genera were targeted for the application of this biolarvicide.

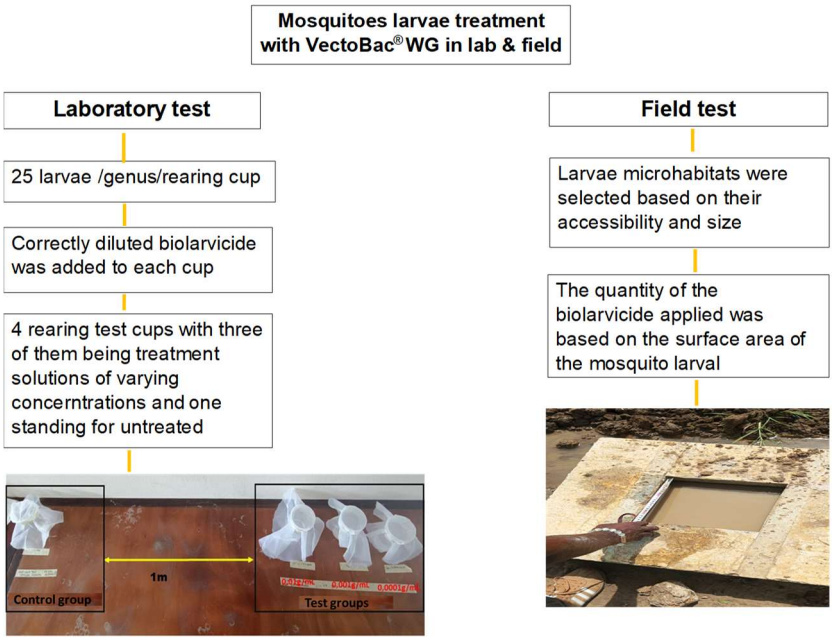

Figure 2. Display of experimental setup to test for the efficacy of VBG on three genera of mosquitoes. 25 larvae were placed in four rearing cups, cup 1 (untreated control group) at a distance of 1m from three treatment groups (group 2: 0.01 g/mL; group 3: 0.001 g/mL; group 4: 0.0001 g/mL). This was carried out for each of the three genera and repeated twice. However, in the field, VBG was dispensed based on the surface area of the different types of larval microhabitats.

2.3. Determination of larval reduction rate

The larval density in the field was measured by counting larvae in five dips [1]. Its efficacy both in the laboratory and in the field was measured in terms of mortality rate, 24 hrs post larval exposure. The larval reduction rate (LRR) was calculated as in Sevidzem et al. [7] as such:

$$LRR = (iD - fD)/iD \times 100$$

where: LRR = Larval reduction rate; iD = initial density; fD = final density.

3. Results

3.1. Characteristics of study population

A total of 872 larvae were reared in the laboratoire d'écologie des maladies transmissible (LEMAT), from March to May 2024 during the rainy season. The number reared and tested by genus is presented in **Table 1**.

Table 1. Mosquito larvae reared and tested in this experiment.

Genus	Number reared and identified	Number tested
Aedes	347	200
Anopheles	266	200
Culex	259	200
Total	872	600

3.2. Bioassays to test the efficacy of VBG

For the bioassay of VBG, in the laboratory, the required dose to kill 88% and 100% of the larvae in rearing cups was 0.001 g/mL and 0.01 g/mL respectively (**Figure 3**). Under field conditions, the percentage density reduction irrespective of the larval microhabitat type ranged from 90% to 100% and the mosquito larval density reduction between test and control groups in the field differed statistically (X^2=34; p = 0.026) (**Table 2**).

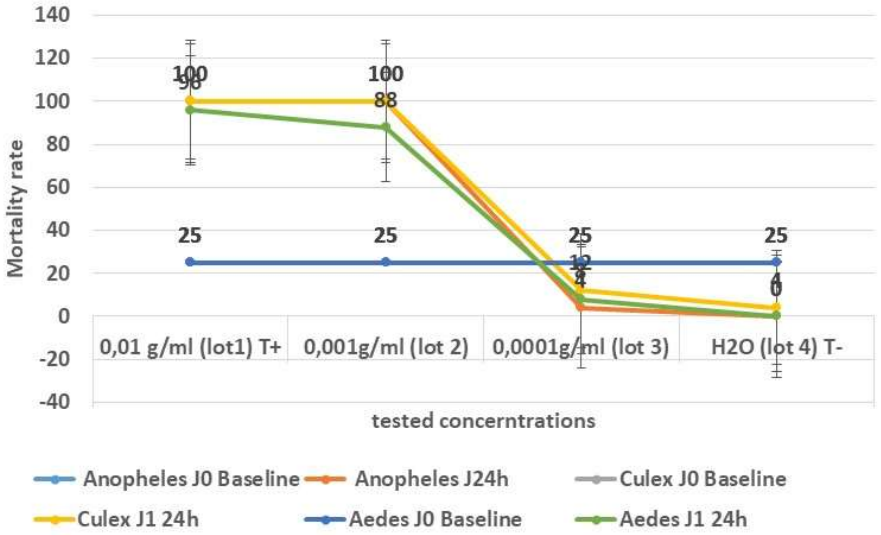

Figure 3. Mortality curve for the three genera of mosquito larvae 24hrs post-exposure to VBG. J0: Treatment day; J24: 24hrs post treatment.

Table 2. Field testing of VBG in different mosquito larval breeding sites behind the Libreville international airport area.

Code	Type	GPS coordinates		Genus	Surface (m^2)	Quantity (g)	Density D0	Density D24h	LRR (%)
		North	East						
1	Water canal	00°28.236	009°24.549	*Anopheles*	1.1	0.022	17	0	100
2	bucket	00°28.237	009°24.546	*Anopheles*	0.2001	0.004	16	0	100
3	bucket	00°28.235	009°24.547	*Anopheles*	0.0855	0.017	1	0	100
4	Surface water	00°28.208	009°24.584	*Anopheles*	0.35	0.069	6	0	100
5	Surface water	00°28.149	009°24.597	*Anopheles*	1.21	0.024	5	0	100
6	Surface water	00°28.120	009°24.601	*Anopheles*	0.029	0.006	1	0	100
7	slab	00°28.112	009°24.602	*Anopheles*	0.015	0.003	5	0	100
8	surface water	00°28.113	009°24.598	*Anopheles*	0.407	0.008	6	0	100
9	car tire tracks	00°28.115	009°24.592	*Anopheles*	0.1	0.002	8	0	100
10	car tire tracks	00°28.116	009°24.590	*Anopheles*	0.027	0.054	1	0	100
11	surface water	00°28.119	009°24.587	*Anopheles*	0.033	0.065	1	0	100
12	surface water	00°28.278	009°24.496	*Anopheles*	0.058	0.012	5	0	100
13	tire	00°28.515	009°24.347	*Aedes*	0.302	0.006	15	0	100
14	tire	00°29.363	009°24.381	*Aedes*	0.302	0.006	10	1	90
15	bucket	00°29.374	009°24.381	*Aedes/Anopheles*	0.102	0.046	8	1	90

Table 2. (*Continued*).

Code	Type	GPS coordinates		Genus	Surface (m^2)	Quantity (g)	Density D0	Density D24h	LRR (%)
		North	East						
16	cut container	00°29.362	009°24.408	*Culex/Anopheles*	0.071	0.011	8	0	100
G 01	tire	00°28.515	009°24.347	*Aedes*	0.302	0.006	29	0	100
G 04	basin	00°29.192	009°24.407	*Culex*	0.204	0.041	45	0	100
G 05	cut container	00°29.374	009°24.381	*Aedes/Anopheles*	0.071	0.011	15	0	100
17	untreated control	00°29.339	009°24.418	*Culex*	0.302	0	15	12	20

The Chi-square test revealed a statistically significant difference ($X^2 = 34$; $p = 0.026$) of VBG effect on the 19 different treated larval breeding sites compared to the control. However, no statistically significant difference ($X^2 = 16$; $p = 0.067$) was recorded when the effect of treatment with the biolarvicide was compared for the 19 treated larval breeding sites. LRR: Larval Reduction Rate.

4. Discussion

The aim of the study was to test the efficacy of VectorBac® in an urban setting. Overall, the mean mortality rates obtained in this study fall within the sensitivity range (80% to 100%) defined by the WHO [6]. Similar studies have been carried out in Senegal, on the genus Anopheles with a mortality rate greater than 80% [8]. Also in Niger, biolarvicides based on *Bacillus thuringiensis* subsp. israelensis (Bactivec and Griselesf) have also proven their effectiveness on *Culex* and *Anopheles* genera even at its very low concentration [9]. As the present pilot study could not evaluate the residual effect of this biolarvicidal formulation, future studies will integrate this aspect.

5. Conclusions

This preliminary study revealed superior sensitivity of the three local genera of mosquito's larvae to VBG in the field and laboratory. However, its residual effect at mosquito larval generic levels still need to be established for Gabon.

Conflict of interest: The authors declare no conflict of interest.

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