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Editorial

Launch of a new journal: *Global Population Perspectives*

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Along with the rapid global change, population dynamics research has become more and more crucial. The world is witnessing unprecedented shifts in population size, age structure, migration patterns, and fertility rates, which have far-reaching implications for economic development, social welfare, environmental sustainability, and public policy. There is an urgent need for a dedicated open access platform that can compile the latest research and insights in the field of demography.

In this context, we are excited to introduce *Global Population Perspectives*. This new journal aims to be a premier venue for high-quality research and comprehensive reviews in population studies. We envision a publication that not only showcases cutting-edge research but also stimulates dialogue and collaboration among scholars, policymakers, and practitioners worldwide.

Our journal will cover a wide range of topics, including but not limited to sociology, economy, culture, and environment of population, with hot topics like fertility trends, aging societies, international migration, etc., being discussed. The journal is set to be quarterly scheduled, releasing each issue in March, June, September, and December.

We are committed to maintaining the highest standards of academic rigor and integrity. All submissions, except for editorials, will be subject to a double-blind peer review process. And we will form an editorial board consisting of renowned experts from all over the world to offer a global viewpoint and to guarantee that every published article meets the highest quality criteria.

We extend a sincere invitation to you, our colleagues in the global population research community, to contribute to *Global Population Perspectives*. Whether you are conducting original research, synthesizing existing knowledge, or offering innovative policy recommendations, your work has a place in our journal. Researchers at every stage of their careers, from up-and-coming academics to seasoned experts, are also encouraged to submit. Hopefully, by working together, we can advance the frontiers of population studies and make a meaningful impact on the world.

We look forward to a bright future for *Global Population Perspectives* and to working with you to shape the future of population research.

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Article

Forced marriage among Somali refugee girls: A qualitative study on poverty, gender-based violence, and human rights violations

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Abstract: The political landscape of the Horn of Africa has been marked by persistent instability over recent decades. This fragility, compounded by recurrent natural disasters, has profoundly impacted civilian populations, exacerbated food insecurity and triggered widespread displacement. Heightened political tensions between federal and regional authorities during the 2020/2021 elections further hindered the implementation of judicial, constitutional, and human rights frameworks. Protracted conflicts and droughts, floods, and locust infestations have intensified the humanitarian crisis, displacing millions. Among the displaced, a significant number of children flee the Horn of Africa to escape poverty, and conflict, and in pursuit of education and a better future. However, these children often become victims of abuse, including sexual and gender-based violence (GBV), exploitation, and forced marriage—a phenomenon that has risen sharply according to recent UN reports. Forced marriage, particularly affecting women and girls, represents a severe form of GBV and a violation of fundamental human rights. Refugee women are especially vulnerable to forced marriage due to economic hardships, patriarchal structures, cultural traditions, and religious pressures. This study explores the phenomenon of forced marriage as a violation of human and children's rights, utilizing oral testimonies from unaccompanied minor refugee girls. The research sample comprised 20 refugee girls aged 16–17, residing in an Accommodation Centre for Unaccompanied Minors in Greece. These girls, originally from Somalia, either experienced forced marriage in their home country or fled to escape impending marriages. The study employed semi-structured individual interviews to gather in-depth insights. The findings reveal interlinked issues of poverty, GBV, the social construction of childhood, and the psychosocial dimensions underpinning the culture of forced marriage. The study also highlights the influence of cultural principles and beliefs in African societies.

Keywords: forced marriage; gender-based violence (GBV); child marriage; poverty; unaccompanied minors; Africa

1. Introduction

Forced marriage is widely recognized as a form of domestic and child abuse and a grave violation of human rights [1]. While arranged marriages are a customary practice in certain cultures, the transition from voluntary participation to coercion—whether physical or emotional—constitutes a clear form of abuse. Research indicates that women are more likely than men to comply with parental wishes regarding marriage due to social pressures, while men are often influenced by societal constructs of pride and masculinity. However, both genders can be subjected to emotional manipulation and coercion [2]. Despite this, girls face disproportionate

harm, as forced marriage severely impacts their access to education, employment opportunities, and personal and financial autonomy.

For many refugee women, forced marriage represents a key factor in their decision to flee their home countries and seek international protection. These women may be escaping coercive marriages or seeking to avoid marriages arranged without their consent. In Somalia, the absence of a legal minimum age for marriage, combined with societal norms, allows for the legalization of child marriage, with some girls as young as ten being married off.

This paper examines the phenomenon of child marriage, highlighting its status as a recognized form of gender-based violence and exploring its impact on human rights and children's rights in the context of Somali refugee girls.

2. Gender-based violence

Gender-based violence (GBV) primarily refers to violence targeted at women and girls, encompassing a broad spectrum of harmful behaviors, including physical, sexual, psychological, and economic abuse (See **Figure 1** for the different types of gender-based violence) [3].

This pervasive practice is one of the most widespread human rights violations globally, transcending social, economic, and national boundaries. The United Nations recognizes GBV not only as a critical human rights issue but also as a global health and development concern, necessitating comprehensive policies, public education, and action programs worldwide [4]. Despite its gravity, GBV remains underrecognized as a human rights violation in many parts of the world.

According to the World Health Organization (WHO), GBV ranks as the fourth leading cause of death for individuals aged 15–44, with over 1.3 million fatalities annually, accounting for 2.5% of global mortality [5]. It is estimated that one in three women experiences physical or sexual violence during her lifetime [6]. Additionally, one in five women suffers sexual abuse during childhood [7].

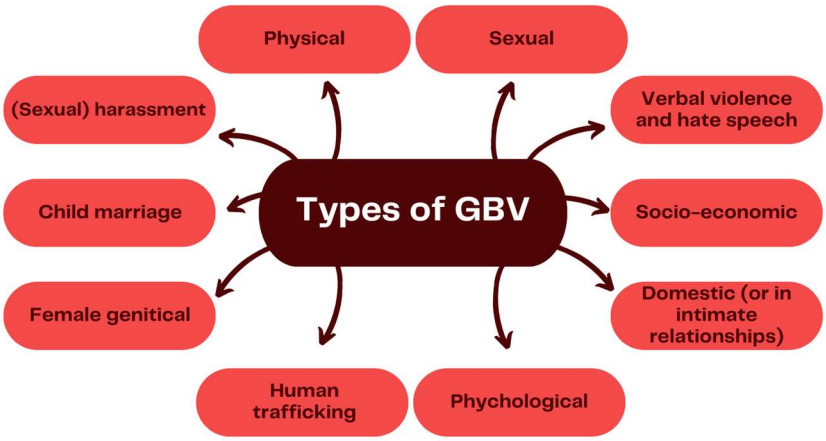

Figure 1. Types of gender-based violence.

Forced marriage in Somalia

Somalia is among the countries with the highest levels of gender inequality, though data capturing recent trends remains incomplete [8]. Forced marriage is

deeply rooted in Somali tradition, often practiced as a means to forge alliances between neighboring tribes. These alliances typically aim to secure access to vital resources such as pastures and water or to consolidate peace agreements [7].

This practice exposes girls to heightened risks of sexual, physical, and psychological violence throughout their lives. Research indicates that girls who marry at a young age are more likely to face abuse, including threats and physical violence, from their husbands compared to those who marry later in life. Furthermore, early marriage significantly disrupts girls' educational trajectories, limiting their access to learning opportunities and perpetuating cycles of poverty. This not only undermines the personal development of individuals but also hampers Somalia's broader economic progress and national development [9].

3. Unaccompanied minor

The United Nations High Commissioner for Refugees (UNHCR) defines an unaccompanied minor as an individual under the age of eighteen—or the age of majority as defined by the asylum country's legal framework—who is not in the care of their parents, a guardian, or any adult legally or customarily responsible for their custody. This definition applies to minors who seek refugee status in their host country [10].

3.1. Child marriage

Child marriage, defined as the marriage or informal union of individuals under the age of 18, constitutes a violation of human rights that disproportionately affects girls in developing countries [11]. Despite global efforts to address the issue, child marriage remains prevalent in many regions, with an estimated 39,000 underage girls becoming brides each day [12]. Forced marriages, which often occur informally and lack official documentation, present significant challenges in obtaining specific and reliable statistical data. This lack of data complicates efforts to understand the problem's scope and develop targeted interventions fully.

3.2. The social construction of childhood

The social construction of childhood is a theoretical framework that examines how societies define and interpret the concept of childhood. This perspective posits that childhood is neither a universal nor a biologically determined phase of life, but rather a social construct shaped by cultural, societal, and historical contexts. The meaning of childhood varies significantly across cultures and periods, reflecting differences in social norms, economic conditions, and cultural values. The concept of childhood is fluid and dynamic, evolving in response to shifts in societal expectations and ideologies [13]. This framework challenges the assumption of childhood as a uniform experience, emphasizing its dependence on broader social and cultural structures.

4. Poverty and hunger in Africa

4.1. Poverty

Poverty remains one of humanity's most critical challenges [14]. Despite the world's vast natural and human resources, severe poverty afflicts millions, particularly in developing nations [15].

In Africa, poverty manifests as the deprivation of essential human needs within communities, including inadequate access to food, clean water, shelter, and nutrition [16]. This issue is especially acute in sub-Saharan Africa, where a significant portion of the population lives in extreme poverty [17].

Poverty is defined as the condition in which individuals or communities lack the financial resources to meet basic living standards and remains a significant challenge in many African nations [18]. The World Bank defines poverty as living on less than US$1.90 per day. People living in poverty are typically characterized by low income and consumption levels, alongside limited access to clean water, adequate housing, nutritious food, proper healthcare, and quality education, among other essentials [19]. The average poverty rate in sub-Saharan Africa (SSA) stands at 41%, indicating that the number of poor people in the sub-region has increased from 278 million in 1990 to 413 million in 2015 [20].

Poverty in Africa is persistent and multidimensional. According to Dabalen and Dang [21], three out of five of Africa's poor are chronically impoverished, meaning they remain poor for several consecutive years. This reflects a deep-rooted structural problem, caused by a lack of resources, limited access to public services and infrastructure, and scarce income-generating opportunities. These challenges are often linked to the geographic location of the poor, which creates a "geographic poverty trap" [22], and the need to protect against income shocks, which leads to what is known as the "risk-induced poverty trap" [23].

The remaining two out of five poor Africans experience transitory poverty, indicating that households and businesses are often in highly unstable environments with limited means to cope. African households are more vulnerable to various risks than those in other regions and exit from poverty is fragile, with many relapsing back into poverty. One particularly destructive factor is the risk of physical insecurity and conflict, which can pull people back into poverty, including those who were previously better off. This cycle of poverty tends to persist, especially in fragile states, where poverty reduction is slower [20].

In 2013, 29% of Africa's poor resided in fragile and conflict-affected areas—a figure projected to rise to 43.6% if current trends continue. Addressing poverty in these regions is crucial for any effective poverty-reduction strategy in Africa. Recent progress indicates that global efforts to fight poverty are beginning to show promising results, with notable declines in the number of people living in extreme poverty in some impoverished areas. However, significant concerns persist, as the world's poorest populations remain concentrated in developing countries [20].

According to Beegle and Christiaensen [20], three key factors have contributed to the slower pace of poverty reduction in Africa:

> *"High Fertility and Population Growth: While Africa's gross domestic product (GDP) growth has been strong in recent decades (with some exceptions in recent years), economic growth per capita has been slower compared to other low- and middle-income regions. Higher fertility rates and faster population growth in African countries have resulted in much lower income per person.*
> *Poor Initial Conditions: Africa's relatively modest per capita household income growth has not led to as significant poverty reduction as seen in other regions, primarily due to the high initial levels of poverty. Limited access to assets, public goods, and services, combined with a lack of good income-earning opportunities for a large portion of the population, restricts many people's ability to benefit from and contribute to economic growth. In many African countries, poverty itself, rather than inequality, is the main barrier to poverty reduction.*
> *Composition of Growth: The structure of Africa's growth has hindered faster poverty reduction, particularly due to the heavy reliance on natural resources and the underperformance of agriculture and manufacturing sectors."*

4.2. Hunger

The Food and Agriculture Organization (FAO) defines chronic hunger as a prolonged insufficiency in daily caloric intake required to sustain a healthy and active lifestyle. According to Adeyeye et al. [16], the minimum daily energy requirement per person is set at 1800 calories. The issue of hunger is particularly acute in sub-Saharan Africa (SSA), where the growing global population is expected to surpass food production capacity in the coming decades. This imbalance is projected to have the most severe consequences in developing regions, especially SSA, where hunger remains a significant public health crisis. Factors such as rapid population growth, inadequate food production, and socioeconomic inequalities exacerbate hunger in the region [24]. Notably, a 1% increase in population correlates with a 0.081% rise in hunger, while a 1% increase in income is associated with a 0.08% reduction in hunger [24]. These findings emphasize the importance of enhancing economic conditions in SSA to mitigate hunger effectively.

Malnutrition, a direct consequence of hunger and food insecurity, is also linked to broader systemic issues, including conflict. Evidence indicates that war significantly exacerbates food insecurity, compounding the challenges faced by vulnerable populations.

The FAO further defines food security as a state in which all individuals have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life [25]. Conversely, food insecurity denotes inconsistent or inadequate access to such resources, impeding normal growth, development, and overall well-being [26]. In 2017, one in four people in SSA were undernourished, representing a third of the global population suffering from chronic hunger. Alarmingly, projections suggest that by 2030, Africa will account for 90% of the world's poorest population [25]. Malnutrition is particularly prevalent among children, with nearly half of South African children under five classified as malnourished. Female-headed households,

disproportionately affected by income, social status, and education disparities, experience higher rates of food insecurity and malnutrition [25]. The primary drivers of food insecurity in SSA include socio-economic factors, climate change, poverty, and systemic inequalities [26]. Moreover, research indicates that pregnant women married before the age of 18 are nearly four times more likely to experience malnutrition compared to those who marry after 18 [27].

Food insecurity also has profound social and psychological implications. Meyer et al. [26] found a strong association between food insecurity and intimate partner violence (IPV). Men unable to fulfil their traditional role as providers often resort to IPV as a means of asserting control within their households. In Tanzania, a region heavily impacted by food insecurity, IPV rates are significantly higher. Hatcher et al. [28] report that 48.4% of partnered men had committed IPV, and 61.4% were food insecure. Their findings highlight a twofold increase in IPV likelihood in food-insecure households, underscoring the broader societal impacts of food insecurity on mental, physical, and social well-being.

Persistent hunger and malnutrition in SSA remain intrinsically linked to poverty. Globally, nearly 795 million individuals suffer from chronic undernourishment, with a disproportionate burden borne by SSA due to entrenched poverty and inequality [25]. In addition to socio-economic disparities, rapid population growth and environmental challenges, including climate change, further exacerbate food insecurity in the region [24]. While the FAO envisions food security as universal and consistent access to safe and nutritious food, this ideal remains unattainable for many in SSA, where one in four individuals were undernourished as recently as 2017, accounting for a third of the global population suffering from chronic hunger [26].

5. Materials and methods

This study aimed to investigate the phenomenon of forced marriages, particularly focusing on its implications as a violation of human rights, with a specific emphasis on children's rights. The research sought to provide an in-depth understanding of forced marriage among unaccompanied minor refugee girls from Somalia residing in an Accommodation Centre for Unaccompanied Minors in Greece.

A qualitative research design was adopted, employing purposive sampling to select participants who met the specific inclusion criteria. The sample consisted of twenty unaccompanied minor girls aged 16–17, who had either been subjected to forced marriage in their country of origin (Somalia) or had fled Somalia to escape impending forced marriages. This sampling method ensured that participants had relevant experiences, aligned with the study's objectives.

Data collection was conducted through individual, semi-structured interviews, each lasting 30 to 60 min. This approach allowed participants to express their thoughts and experiences in detail while allowing the researcher to address key research questions systematically. The interviews explored the participants' personal experiences with forced marriage, the socio-cultural factors contributing to the practices, and the challenges they faced both before and after fleeing their countries.

The interview guide, developed based on existing literature, was designed to capture both the subjective and objective aspects of forced marriage. It included open-ended questions that encouraged participants to reflect on their personal histories, current circumstances in Greece, perceptions of forced marriage, and the support systems they accessed after fleeing Somalia.

Written informed consent was obtained from all participants prior to the interviews. For minors, assent was also secured alongside parental or guardian consent, as required. All interviews were conducted in a safe, confidential environment, with participants explicitly informed on their right to withdraw from the study at any stage without consequences.

To ensure the ethical integrity of the research, qualified psychologists were present during all interviews to address any psychological or emotional distress that might arise. Additionally, professional interpreters facilitated accurate communication, ensuring participants fully understood the questions and expressed themselves without language barriers.

The data collected from the interviews was transcribed and analyzed using thematic qualitative analysis to identify recurring patterns, themes, and insights. The process began with the transcription of interview recordings, followed by multiple readings of the transcripts to identify potential themes. These initial codes were forwarded to the primary researcher for further refinement. In the second stage, both the primary and final researchers reviewed the initial codes collaboratively, ensuring that the diversity of the data was preserved while consolidating overarching elements into higher-order subthemes. The research focus informed this step on the experiences of forced marriage and its impacts on participants' lives.

In the third stage, the primary and final researchers analyzed the data to identify illustrative quotes aligned with the overarching themes. Subsequently, the themes underwent a thorough review, refinement, and definition process, culminating in the final naming of each theme. Once the themes were finalized, the report's write-up commenced, guided by the finalized thematic structure.

This approach ensured a rigorous and systematic exploration of the data, maintaining fidelity to participants' voices while drawing out meaningful patterns and insights relevant to the research question.

Triangulation was employed by cross-checking findings with relevant literature to enhance the validity and reliability of the study's conclusions. These methodological steps ensured a robust and ethically sound approach to exploring this critical issue.

6. Results

The research findings underscored critical issues surrounding gender-based violence, the social construction of childhood, and the psychosocial dimensions of forced marriage within the context of Somali culture. These findings were interpreted through the lens of cultural principles and deeply rooted beliefs. Simultaneously, the study illuminated the objectification and "commercialization" of the female body, often justified by appeals to cultural traditions, religious practices, and notions of honor. Such practices reflect the intersection of societal norms and

systemic inequalities, revealing the complex interplay between cultural heritage and the perpetuation of harmful practices (See **Figure 2** for the most used words and phrases in the testimonies).

The analysis produced four themes.

6.1. Patriarchy and decision-making in forced marriages

Family as the decision-maker: In Somalia, decisions regarding marriage are made exclusively by male family members, such as fathers or other male relatives, with no regard for the desires or opinions of the girls involved.

"The family decides for us, and only men have power. You either marry, or you are thrown out of the house." (K, 2)

"Boys are given everything; girls are worth nothing." (K, 4)

Marriage as a political tool: Marriage is often used as a political strategy to restore peace between clans, with girls being sacrificed for the "greater good".

"After a war, they choose girls from one clan to marry boys from the other clan." (K, 1)

6.2. Violence and coercion

Physical and psychological abuse: Girls who are forced into marriage often experience severe physical abuse, sexual violence, and psychological trauma, inflicted either by their husbands or by their families to ensure compliance.

"He raped and beat me. If I said no, he would beat me more." (K, 7)

Use of sedatives for control: The use of drugs to subdue women and prevent their escape highlights the extent of control exerted over them.

"He gave me pills that made me sleep for two days. They do these so women can't escape." (K, 9)

Consequences of refusal: Refusing a forced marriage results in extreme measures, including imprisonment, food deprivation, and severe mental and physical exhaustion.

"They lock you in a small room with little food and water until you're exhausted and agree." (K, 6)

6.3. Lack of institutional protection

Absence of legal and institutional support: Women and girls in Somalia receive no legal protection, even when they report abuse. Authorities often reinforce patriarchal norms instead of safeguarding victims.

"I went to the police after he beat me badly, and they said, 'What are you doing here? Go back to your husband'." (K, 3)

Male-dominated authority: Decisions are made exclusively by men, leaving women powerless and dependent.

"Boys get everything, while girls have no rights or choices." (K, 10)

6.4. Psychological impact and resistance

Trauma and mental breakdowns: Forced marriages and the conditions surrounding them cause profound psychological damage, including anxiety, depression, and self-harm.

"Girls who are imprisoned come out trembling, biting their hands and legs." (K, 5)

Relief through escape: For those who manage to escape, the newfound freedom brings a sense of safety and relief, despite the lingering emotional scars.

"*I feel happy, free, and… relieved."* (K, 9)

This thematic analysis demonstrates that forced marriage in Somalia is deeply rooted in patriarchal systems, perpetuated by the absence of women's rights, institutional support, and societal protections. The consequences for girls are severe, encompassing physical violence, psychological trauma, and loss of autonomy. Despite these challenges, many women aspire to freedom and autonomy, advocating for systemic change. Their call for an end to forced marriage and greater respect for women underscores the urgent need to address these deeply ingrained practices and promote gender equality and human rights.

Moreover, both marriage and its denial are followed by various forms of violence either in the same: *"They lock you in a tiny space and give you little food and water without seeing the sun, until you are exhausted and accept to get married. There is no choice. Either you die or you get thrown out on the street or you get married. Many girls imprison them until they change their minds and say yes…"* (K, 2) or to their families: *"My dad refused. She told them no; I'm not marrying her. They told him, 'Think again, and we'll talk again in 4−5 days. We'll take it ourselves if we don't take it from you'. I ran away and my father was taken by Al-Shabaab (an Islamist terrorist organization) and imprisoned. Since then, I don't know where it is…"* (K, 5)

The gender binaries of privilege and rights and their identification with male domination are reproduced by the girls themselves as cultural elements, *"... The man will not respect you, because he paid for you and therefore you are his, his property. Secondly, he speaks, and you listen. He picks you up and uses you without asking you anything. When they want to have sex, they do. They don't ask. And think about how difficult it is with FGM. Some people don't accept a woman having surgery to 'open up' before sex. Do you understand what that means? What pain and what blood?"* (K, 3)

The psychological pressure of forced marriage is strongly reflected in the girls: *"I had a girl in the neighborhood, 14 years old, who had been imprisoned because she did not want to get married. As soon as they freed her, she had gone out and was shaking and biting her hands."* (K, 10), and follows them on their way: *"For my parents I know that I have died. But as long as I live, I will never forgive them for what I went through because of them."* (K, 8)

Through the interviews, issues of objectification of the female body and its "commercialization" for reasons of respect for cultural traditions, customs, and religious beliefs, invoking honor, as one unaccompanied minor told us, *"When I entered Greece and was walking to reach the camp, I heard some men calling us and*

a pregnant woman. They told us, 'Go back to Somalia. Because of you, because you come to Europe and talk about forced marriages, you get asylum, and we get rejection. Because of you we do not go to Europe'." (K, 10); *"…But consider that it's not just parents who give money to marry us. They sell us for camels, cars or guns. Of course, what do you think? They exchange us."* (K, 6)

Figure 2. The research's word cloud.

7. Discussion

Forced marriage is a multifaceted social phenomenon sustained by a confluence of cognitive, emotional, behavioral, and cultural factors. A deeper understanding of these dimensions' sheds light on the complex influences perpetuating this practice.

The causes of child marriage are deeply interconnected, with socioeconomic factors such as poverty, rural employment, and limited access to education playing a pivotal role. The consequences for girls are profound and far-reaching, impacting their health, human rights, and overall development. Evidence consistently links child marriage to school dropouts, gender-based violence, social isolation, poor mental health outcomes, and adverse maternal and child health outcomes.

As this research has shown, in forced child marriage, individual consciousness and the capacity of the child to comprehend and resist the decision are largely bypassed, as marriage is often framed by families as the "lesser evil" or as a pathway to a better future, with parents acting as primary decision-makers who frequently overlook the child's preferences, agency, and needs. Economic pressures and social expectations further drive this phenomenon, as families often view marriage as a means of financial relief, with the child seen as a "sacrifice" to address economic needs, while social pressures compel girls to conform to societal expectations of proving their worth as future wives and mothers.

In the behavioral dimension, young girls often lack the agency to express their desires or objections regarding impending marriages. The societal expectation of marriage becomes an unalterable path, leaving them unable to advocate for their own interests or safety. Post-marriage, these girls frequently face educational deprivation, as they are withdrawn from school to adhere to societal norms that prioritize family formation and societal "honor" [29].

Culturally, early marriage is entrenched as a normative practice, framed as the girl's predetermined "fate". This perspective ensures the girl's and her family's social acceptance, as it aligns with traditional expectations of obedience, familial respect, and readiness for motherhood.

Parents are referred to as the main decision-makers, who expect economic and social benefits from the forced marriage of their children. Conversely, the lack of justice for girls and their ability to "set life goals and act upon them", is often reported in the literature to contribute to child marriage, as it affects the ability to resist unwanted marriage proposals [30]. Additionally, early marriage is frequently driven by families' desires to achieve economic and social security or to avoid the perceived shame of out-of-wedlock births. Within many cultural and religious contexts, early marriage is deemed essential, as women's value is traditionally tied to their reproductive roles.

What can be done to eradicate child marriage? Interventions show that legal and policy framework reform is a necessary but insufficient part of the response [31]. The most effective interventions empower girls by providing them with information, skills, and supportive networks, enhancing access to quality formal education, and offering financial incentives to encourage families to keep girls in school or delay marriage. It is equally important to raise awareness among parents and community members about the detrimental impacts of child marriage. Shifting societal norms to redefine the transition to adulthood without the need for marriage involves engaging in dialogue with influential religious and community leaders who play a pivotal role in shaping these cultural practices.

8. Conclusion

The interwoven challenges of poverty, hunger, early, and forced marriage present some of the most pressing human rights and public health crises in Africa. This paper highlights the systemic nature of these issues, underscoring their roots in socioeconomic inequities, gender-based violence, and deeply entrenched cultural practices. Poverty and food insecurity not only exacerbate the vulnerabilities of women and children but also perpetuate cycles of marginalization, as seen in the prevalence of child and forced marriages in regions like Somalia.

Forced marriage, particularly among refugee populations, reflects the intersection of poverty, patriarchal norms, and the commodification of young girls as economic assets. These practices strip individuals of agency, deny them access to education and economic opportunities, and impose severe physical and psychological burdens. The testimonies of Somali refugee girls provide vivid illustrations of these practices' profound impact on individuals and their communities.

Tackling these interconnected challenges requires a multifaceted approach. Policies must address poverty and food insecurity through investments in education, healthcare, and sustainable livelihoods. Legal and policy frameworks must prioritize the eradication of child and forced marriages by holding perpetrators accountable while empowering girls and their families. Community-driven initiatives that engage

local leaders, amplify the voices of survivors, and shift societal norms are also critical in dismantling harmful traditions.

This study contributes to the broader understanding of these interrelated issues, emphasizing the need for holistic, context-sensitive interventions. Addressing poverty, hunger, and gender-based violence is not only a moral imperative but also a prerequisite for sustainable development and the realization of fundamental human rights across Africa.

9. Limitations and future research directions

While this study provides valuable insights into the experiences of forced marriage among women and girls in Somalia, several limitations must be acknowledged. The sample size was limited, focusing primarily on participants from specific regions or communities, which may restrict the generalizability of the findings to other regions or cultural contexts. Additionally, the study relies on self-reported narratives, which may be influenced by memory recall issues, emotional distress, or a desire to portray experiences in a particular way. Participants were selected purposively based on their willingness and ability to participate, potentially excluding individuals who faced extreme constraints or did not have the opportunity to escape forced marriage. Furthermore, despite the use of interpreters, some nuances of language or cultural expressions might have been lost during translation, potentially affecting the interpretation of the data. Lastly, discussing sensitive topics such as forced marriage, violence, and trauma poses ethical challenges and may limit the depth of information participants are willing to share.

Future research could address these limitations and explore new dimensions to enhance our understanding of forced marriage. Expanding the sample to include participants from diverse regions, countries, or cultural contexts could provide a more comprehensive understanding of forced marriage as a global issue, while comparative studies might reveal contextual differences and commonalities.

By addressing these limitations and pursuing these future research directions, we can develop a more nuanced understanding of forced marriage and create impactful interventions to protect and empower vulnerable populations.

Author contributions: Conceptualization, ABV and CS; methodology, ABV and NK; validation, AP and AG; formal analysis, ABV and AP; investigation, AP and AG; data curation, ABV, AP, AG and AD; writing—original draft preparation, AP, GTZ, AG, NK and AD; writing—review and editing, ABV and CS; visualization, ABV; supervision, CS; project administration, ABV. All authors have read and agreed to the published version of the manuscript.

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Article

Understanding Canadian ageing workers' perceptions of workplace changes caused by COVID-19

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Abstract: Today's workers are remaining in the workforce longer than previous generations, resulting in a growing ageing workforce. However, the COVID-19 pandemic has made retaining older workers more complex. Ageing workers were particularly vulnerable to the virus, which heightened their fear of infection and reinforced employers' negative perceptions about their performance due to health concerns. To better understand the challenges faced by ageing workers, we conducted a survey investigating their perceptions of workplace changes caused by COVID-19. The survey instrument was systematically developed through a comprehensive literature review to ensure the clarity and relevance of questions. Our findings suggest that both health conditions and organizational support deteriorated between the pre- and post-COVID-19 periods. Interestingly, the number of respondents who felt comfortable with technology increased after COVID-19, indicating a growing adaptability among Canadian ageing workers.

Keywords: ageing workforce; COVID-19; physical and cognitive change; discrimination; technological change; social and organizational support

1. Introduction

The COVID-19 pandemic had far-reaching effects globally, disrupting not only public health but also economic systems, labour markets, and social structures. The virus's high contagion rate and mortality risk [1] triggered widespread lockdowns, travel restrictions, and business closures—catalyzing a global economic downturn [2–4]). In many countries, the economic disruption resembled the 2008 financial crisis but introduced new challenges, particularly for ageing populations regarding health risks and labour force participation.

As existing economic policies proved inadequate [5,6], there was increased pressure on policymakers to implement structural reforms. One critical area of focus became the participation of older adults in the labour market [6,7]. The pandemic exacerbated this challenge, as retaining ageing workers became increasingly difficult due to heightened vulnerability, job displacement, and reluctance to return to in-person work environments [8,9].

In Canada, Statistics Canada data revealed a notable decline in labour force participation among ageing workers during the pandemic [10]. **Figure 1** reveals that, between 2014 and 2019, the annual employment growth rate for Canadians aged 60 and above remained consistently positive for both genders. However, in 2020, it dropped to 3.3% for men and 7% for women, with women experiencing a steeper decline. According to Scott [11], this decline reflected broader labour losses among women: 2.8 million Canadian women either lost jobs or had reduced hours in March

2020 alone.

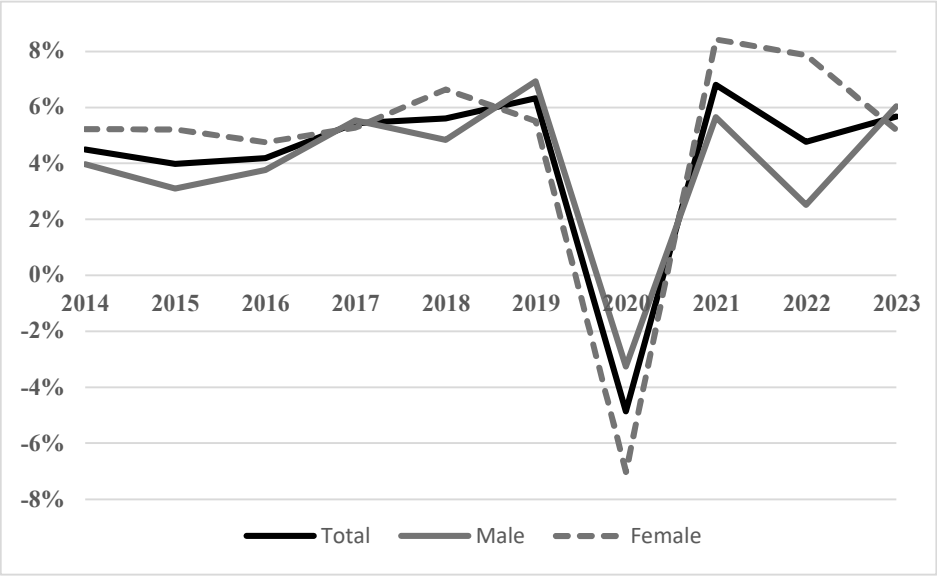

Figure 1. Annual employee growth rate for employees aged 60 and older in Canada (%).
Source: Authors' own computations based on data from International Labour Organization (ILO) [12].

Employment losses overall were steep. Lemieux et al. [13] found that total hours worked in early 2020 dropped by 32%—a sharper decline than in previous recessions. Older workers, especially older women, experienced slower re-employment rates and higher rates of labour market exit [14]. Schuster et al. [9] reported that many older workers retired not by choice, but due to prolonged unemployment. Cui [14] found that involuntary exits were most common among low-income, older women.

Interestingly, participation among older workers began to recover in 2021. Camille [15] reported that the Canadian government invited recently retired frontline workers to return to the labour force to meet COVID-related service demands. This likely contributed to the rising employment rates for those aged 60+ between 2021 and 2023. However, this return may be temporary. Concerns around health, burnout, and readiness for retirement persist, and long-term participation remains uncertain. Additionally, many older workers had to adapt quickly to remote work and digital platforms—a major shift that posed significant challenges [5].

2. Literature review

2.1. Structural shifts and policy gaps

Beyond the immediate crisis, the post-pandemic labour market accelerated structural trends such as automation and digitization. These changes have disproportionately impacted older workers, particularly those in physically demanding or lower-skill jobs, increasing the risk of job displacement and early retirement [16]. While there has been growth in age-friendly occupations across Canada and other developed countries, older men and non-degree holders have benefited less from these developments [17].

In addition to labour market challenges, there is a significant lack of Canada-

specific empirical research on the experiences of ageing workers. Lagacé et al. [10] found that from 2009 to 2019, Canada produced fewer studies on this topic than other developed countries, particularly in comparison to Europe. This is concerning, as Canada's ageing workforce is diverse in terms of health, educational attainment, ethnicity, and work history. Applying foreign findings may not fully capture the Canadian context.

Tiwana et al. [18] further observed that pandemic-response policies in Canada failed to address the equity needs of older and marginalized populations—particularly immigrants and women in precarious employment. This oversight likely exacerbated labour market exclusion during the crisis and may have long-term implications for income security and re-employment prospects for ageing Canadians.

Given these gaps, the purpose of this study is to explore the lived experiences of Canadian ageing workers before and after the COVID-19 pandemic. Specifically, it aims to assess how the pandemic influenced their employment status, work environments, and willingness to remain in the labour market.

This paper is organized as follows: Section 2 reviews existing literature on the challenges faced by ageing workers in remaining employed. Section 3 outlines the research design, eligibility criteria, and recruitment process. Section 4 presents the analysis and key findings. Section 5 summarizes the study's conclusions and policy implications.

2.2. The impact of COVID-19 on the ageing workforce

The COVID-19 pandemic inflicted severe negative economic consequences on people worldwide. According to Martin et al. [4], the disease prevention measures implemented in the early stages of the pandemic—for example, lockdowns, working from home, and mass quarantine—were problematic for many members of the working population. In addition, mass layoffs, downsizing, furloughing, and wage reductions became increasingly commonplace [19,20]. In fact, these cost-cutting strategies have put further pressure on workers. Clarke and Fields [21] estimated that 3.4 million employees lost their jobs at the beginning of the pandemic in Canada alone. As a result, many workers struggled to meet their financial commitments, and many had to resort to using their savings [22]. von Wachter [23] estimated that the pandemic-related lifetime earnings losses of workers in the USA could amount to as much as US$2 trillion.

The threat of the virus also affected workers' health and well-being and their motivation to remain in the workforce [24,25]. The increase in the reported death rates among the ageing population due to COVID-19 has created fear among ageing workers of being infected, considering their vulnerability to the virus. The fear of being infected, along with the challenges to learning new technology in a short period of time, may increase the stress level of the ageing workers and subsequently affect their productivity.

Therefore, mass layoffs and voluntary redundancies significantly reduced economic growth in many countries [2–4]. Apart from the mass layoffs, the threat of the virus has worsened the workers' health and significantly affected their well-being and motivation to remain in the workforce [24,25]. Therefore, mass layoffs and the

voluntary exit of workers from the workforce have significantly reduced the number of labourers in the labour market.

According to the Bank of Canada [26], the COVID-19 pandemic has affected every sector of the Canadian economy, with some sectors—for example, the energy, travel, hospitality, and service industries—being particularly severely affected. To support the affected sectors, the Bank of Canada subsequently lowered interest rates by making credit affordable [26,27]. While the availability of credit helped many industries to recover from the economic fallout of the pandemic, others are still struggling because of the fall in the labour supply [5,24,25]. Therefore, government agencies are bound to implement policies to overcome the shortage.

Since workers have different needs and demands, there is a need for targeted support mechanisms that consider the unique circumstances of each age group [28]. In particular, deteriorating health, fear of technology, and age discrimination are factors associated with ageing workers, whose needs are often seen as more challenging than those of other groups of workers [9,29,30]. The following section looks at how the pandemic influenced the participation of ageing workers through their physical and cognitive health, ability to cope with technological advancements, experience of discrimination, and level of social and organizational support in the workforce.

2.3. How COVID-19 influenced ageing workers' workforce participation

Numerous studies indicate that ageing workers' decisions to remain in, or leave, the workforce were influenced by their physical and cognitive health, ability to cope with technological advancements, their experience of discrimination, and their level of social and organizational support [7,31–34]. The collective impact of these factors created a unique set of challenges for ageing workers during COVID-19 [9,16,24,35,36]. **Figure 2** illustrates the complex interplay of the individual, organizational, and social factors that influenced the ageing workers' experience in both pre- and post-COVID work environments.

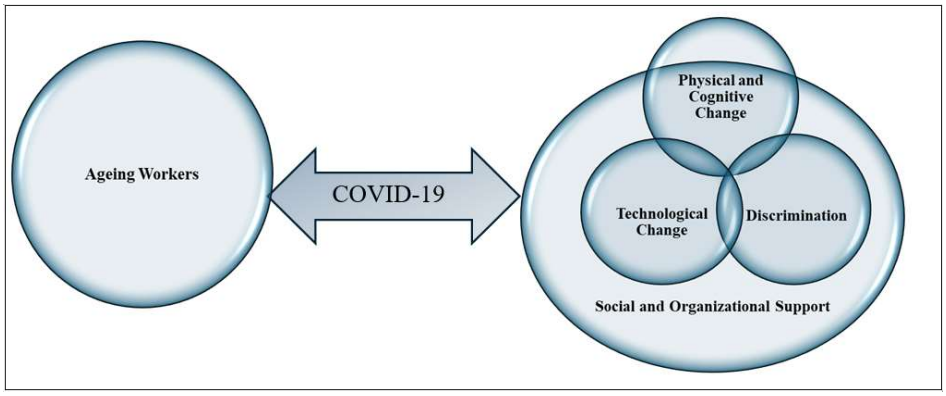

Figure 2. Factors that influenced the performance of ageing workers.
Source: Authors' own design.

2.3.1. Physical and cognitive change

The mortality risk of the COVID-19 virus was more significant for ageing workers, who were more likely than their younger counterparts to have age-related

immune system challenges and underlying conditions that placed them at higher risk of contracting the disease [24,35]. Many ageing workers reported health conditions that limited their work abilities due to COVID-19, with manual workers facing higher risk factors than other workers [29,37]. Apart from the change in health conditions due to their age, the new organizational set-up has also increased the psychological distress of the ageing workers.

According to Losada-Baltar et al. [38], psychological distress was widespread among the ageing workforce during the pandemic, exacerbated by negative self-perceptions of ageing, age discrimination, age-related stereotypes, and social isolation. The author further stresses that the physical and psychological challenges were compounded by the disruption of regular routines and social connections, which intensified feelings of isolation and anxiety. A study conducted by Pit et al. [8] among ageing workers across 15 countries revealed that they experienced ageism, heightened health risks, and psychosocial concerns during the pandemic. As a result, the pandemic created a pervasive sense of insecurity and fear among ageing workers, further reducing their ability to adapt to the new working environment and remain engaged in the labour market [5].

2.3.2. Technological changes

The increasing integration of technology in the workplace presents significant challenges to the ageing workforce, many of whom have inadequate technological literacy [39,40]. Even prior to the pandemic, numerous studies indicated that cognitive decline associated with ageing diminishes the ability to process highly complex information (cognitive skills discussed in the articles include memory, problem-solving, speed processing, attention, reasoning, and sensory perception) [31,33,40], a critical skill for mastering new technologies. According to Aisa et al. [16], technological advancements discourage less skilled ageing workers from remaining in the workforce. The COVID-19 pandemic intensified these challenges by accelerating the rate of digital transformation and necessitating an abrupt shift to remote work for many people. The rapid switch to diverse digital platforms for remote work significantly strained many ageing workers' technical abilities and affected their participation levels [41]. Furthermore, digitization substantially changed many jobs and work environments [19,42]. Workers aged 55 and older were more at risk of being replaced by technology, a phenomenon termed the "dual threat of aging and technology" [43]. The rise in absenteeism among ageing workers made them less productive than other age groups [44]. As a result, many developed countries have invested in adopting automation technologies to replace ageing workers [16].

Specifically, 14.6% of workers aged 55 and older were at high risk of their job changing because of technology, compared to 7.6% of workers aged 25–34 and 10.1% of workers aged 35–54 [45]. This disparity underscores the amplified vulnerability of older workers in the evolving digital landscape.

2.3.3. Discrimination

Age-related discrimination in the workplace, or workplace ageism in overt or covert forms, has been a persistent issue for many years [34,46]. Studies have shown that intergenerational conflict due to ageism negatively impacts ageing workers' health, stress levels, career advancement, and job security [47,48]. Negative

stereotypes and biases against ageing workers became more prominent during the pandemic, as ageing workers were perceived to be less adaptable and less productive than their younger counterparts, leading to their being increasingly marginalized in the workplace [29,30]. Furthermore, as companies focused on pivoting to digital options as quickly as possible during the pandemic, resources were stretched immensely [49]. Consequently, the cultural aspects of the work environment were often neglected, and creating supportive policies and programs for ageing workers during this period was not a priority [49]. Thus, the two-pronged impact of peer discrimination and managerial neglect during the pandemic led to job dissatisfaction and increased turnover among ageing workers [9,34,50].

2.3.4. Social and organizational support

Despite the well-known vulnerabilities of ageing workers, many support services and programs were not readily available to them during the pandemic [36]. This lack of support highlighted gaps in workplace accommodations and exacerbated the challenges older employees face in adapting to a rapidly changing work environment. The level of social and organizational support they experienced dictated their working conditions, which in turn affected their ability to improve their technological literacy, experiences of discrimination, and overall physical and psychological well-being [51–55]. For example, the lack of age-appropriate technological upskilling led to ageing workers' exclusion from social and organizational support services that were provided virtually—for example, psychosocial services and career advancement opportunities [52–54]. This exclusion further marginalized ageing workers, limiting their access to resources that could have mitigated the negative impact of the pandemic on their future employment prospects.

Moreover, inadequate management safeguards against changes to roles and responsibilities compelled some workers to retire earlier than planned or expected [55]. Notably, the work environment, age-appropriate HR policies, strategic management support, and perception of being valued were found to affect the ageing workforce's well-being more than their physiological age did [51]. Developing comprehensive support systems that address these aspects of the workplace experience can play a crucial role in promoting the well-being and productivity of ageing workers and will ultimately benefit organizations as a whole. Thus, robust support mechanisms are a crucial tool to ensure that ageing workers remain in the labour market even during challenging times.

In sum, the labour force participation of ageing workers during the pandemic was significantly influenced by the nuanced dynamics of their physical and cognitive health, technological change, experiences of discrimination, and social and organizational support. The diagram (see **Figure 2**) emphasizes the crucial role that social and organizational support plays in mitigating or aggravating these types of challenges, especially in atypical circumstances such as the COVID-19 pandemic. This model underscores the need for a proactive approach to addressing the unique needs of ageing workers through targeted interventions and supportive policies. Strategic support systems—based on, for example, age-responsive policies and upskilling programs—and a safe and inclusive work environment can help ageing workers better navigate the modern workplace. Holistically addressing the interrelated

factors that contribute to the workplace experience of ageing workers is crucial for sustaining and fully valuing their economic contributions, thus fostering a productive and resilient labour force and improving the quality of life for ageing workers. At the same time, the workforce would remain diverse, skilled, and adaptable in the face of future crises.

3. Research methodology

Our study was designed to fill a knowledge gap by providing empirical evidence about older workers' perceptions of workplace changes caused by COVID-19. The experiences of this particular age group will provide helpful information to use in drafting effective policy plans to encourage ageing workers to remain in the workforce beyond their official retirement age. To be eligible to participate in the study, participants had to be English-speaking adults aged 65 and older who had been employed full-time in Canada since at least 2019. Individuals who had left the Canadian workforce in 2019 onwards were not eligible to participate because our objective was to identify Canadian ageing workers' experiences and challenges in post-pandemic work settings. Given that workers who work for family or friends may have certain privileges, such as a good relationship with their employer, and chances of them being discriminated against will be low [56]. Therefore, we excluded individuals who work for family members or friends to help ensure that the responses reflected more generalized experiences of ageing workers in traditional employment settings. The survey instrument was systematically developed based on an extensive review of relevant literature (refer to **Figure 2**). A thorough review of the preliminary survey instrument resulted in refinements in wording and the addition of items to better capture workplace experiences during the pandemic.

The data were collected through an online survey hosted by Qualtrics (The researchers completed the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (TCPS 2: CORE) on 6 October 2021, and received a Certificate of Ethics Review prior to the study. This ensured that our research was conducted in accordance with the highest ethical standards, respecting the rights and well-being of our participants). (Qualtrics is an online survey tool used to build and distribute surveys and collect responses to survey questions). We conducted our online survey anonymously to encourage participants to provide honest responses without worrying about being identified (No identifying information (names, locations, IP addresses, dates) was collected. Anonymous surveys allow participants to respond to sensitive issues relating to their working lives without fear of being identified). Using an anonymous survey format also minimizes the risk of social desirability bias and encourages more truthful reporting of potentially sensitive issues such as discrimination and other workplace challenges.

Convenience sampling was used to recruit the participants through online advertisements on social networking platforms—for example, Facebook, Instagram, and LinkedIn—classified sites—for example, Kijiji and Craigslist—and flyers in public areas—for example, grocery stores and community centres. To broaden our participant, reach and enhance sample diversity, snowball sampling was employed by encouraging respondents to disseminate the survey within their personal and

professional networks.

The survey was made available throughout Canada between 15 March 2023 and 15 March 2024. Interested participants signed an informed consent form that explained how their responses would be kept anonymous. A set of screening questions was used to ensure the participant was a Canadian ageing worker. At the end of the survey page, a thank-you note was shared with all the respondents for taking the time to participate in the survey. We took this thorough approach to data collection with the aim of building a comprehensive understanding of the issues at hand that could then provide a strong foundation for subsequent analyses and policy recommendations.

4. Empirical results

A total of 500 individuals expressed interest in participating in the survey. However, 53 of them were under the age of 65 and were therefore not included in the study. Of the 447 participants aged 60 and above, 352 completed the survey, while 95 chose not to participate after reading the informed consent form. According to Tabanao [57], as of 2022, nearly one million individuals aged 65 and older were employed in the Canadian labour market. MacEwen [58] stressed that the majority of employees aged 65 and older in Canada are not full-time employees, and only 58% of employees aged 65 and older have been in the workforce as full-time employees since 2011. While the absolute number of ageing workers is significant, their distribution across full-time employment remains low. Since full-time employees work longer hours, their experience and challenges will help us understand the issues ageing workers face in detail. Therefore, based on our inclusion criteria, we were confident that the sample size for our study adequately represented the population of English-speaking adults aged 65 and older who have been employed full-time in Canada for at least five years. The sample size provided sufficient data for drawing meaningful conclusions about full-time ageing workers' challenges and collective experiences in pre- and post-pandemic times.

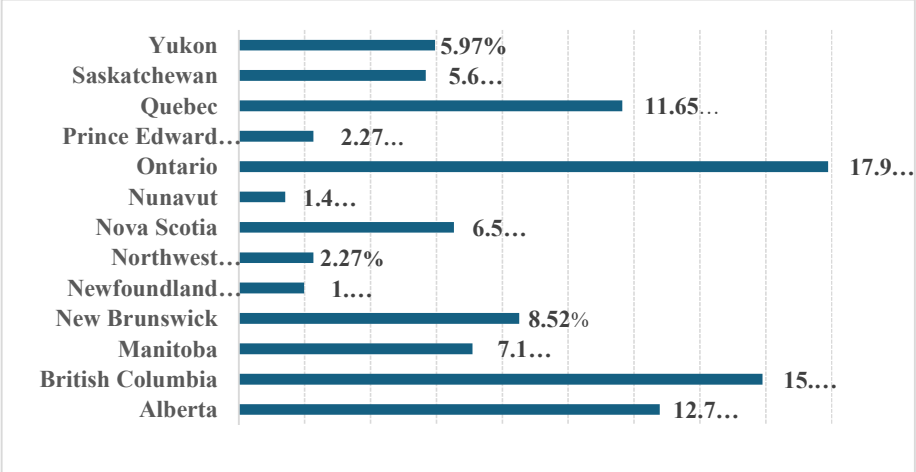

Figure 3. Geographical distribution of responses.

The survey questionnaires were distributed across Canada, covering all provinces and territories. **Figure 3** illustrates the number of respondents from each province and territory, providing a clear representation of the geographical distribution of responses.

Ontario, British Columbia, Alberta, and Quebec had the highest response rates, with 17.9%, 15.91%, 12.78%, and 11.65% of the total respondents, respectively. These provinces contributed the majority of survey responses, reflecting their larger populations and engagement in the study.

We also collected data from respondents based on the sectors in which they work. **Figure 4** shows the highest number of responses from employees in the Health Care and Social Assistance, Educational Services, Accommodation and Food Services, and Public Administration sectors, with response rates of 13%, 11%, 9%, and 9%, respectively. Our results indicate that most respondents are employed in the service-based industry, highlighting its significant representation in the survey.

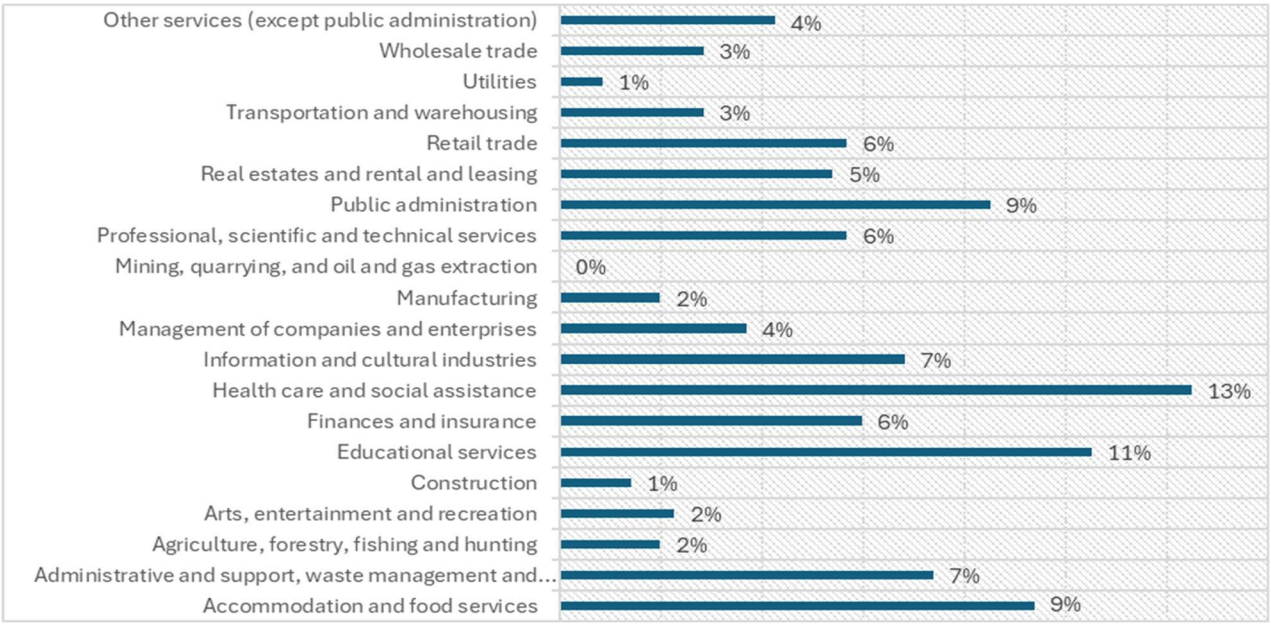

Figure 4. Respondents based on the sectors.

4.1. Fear of COVID-19

Since COVID-19 was a new disease, there was initially little knowledge about its symptoms, long-term impact, and recovery process [1]. Ageing workers were therefore concerned about being exposed to the virus [8]. The fear of staying in the workforce during the pandemic is expected to increase the risk of exposure. As a result, many ageing workers have chosen to leave the labour market [9,54]. Because ageing workers are at a higher risk of COVID-19, employers have also expressed concern about hiring them [9].

Table 1 demonstrates the participants' responses to the questions related to their decision to continue work during COVID-19. Overall, 80.57% of respondents stated that they were exposed to or infected by COVID-19, and 72.34% said that the pandemic affected their inclination to return to work after being infected with COVID-19. Furthermore, 56.57% of participants said the pandemic would affect their decision to continue working even if they did not contract the disease. Hence, as noted by Schuster et al. [9], it is evident that the pandemic has instilled fear among ageing workers to remain in the workforce. These findings indicate a pervasive sense of vulnerability and uncertainty among ageing workers, which could have long-term

implications for their future labour market participation and mental health.

As **Table 1** shows, 51.14% of participants reported being laid off during the COVID-19 pandemic, and 78.69% said their job description changed since COVID-19. In fact, Lemieux et al. [13] reported a 12.1% decline in employment among Canadians aged 50 and above during the first months of the COVID-19 crisis. These results align with the argument that many companies are reluctant to hire ageing workers because of their health risks and high absenteeism due to illness [29,37]. This reluctance reflects broader systemic issues within the labour market that disadvantage older workers, further complicating their efforts to remain employed during and after the pandemic.

Table 1. Responses showing the fear of participating in the labour market due to COVID-19.

Item	Yes	No	Prefer not to answer
Have you been exposed to or infected by COVID-19?	277 (78.69%)	75 (21.31%)	0 (0%)
If YES, did this affect your inclination to return to work (either on-site, blended, or virtually)?	157 (56.68 %)	120 (43.32%)	0 (0%)
If NO, is the risk of COVID-19 infection affecting your decision to continue working?	30 (40%)	41 (54.67%)	4 (5.33%)
Do you feel your job description has changed since COVID-19?	255 (72.44%)	97 (27.56%)	0 (0%)
Have you been laid off during the COVID-19 pandemic?	180 (51.14%)	172 (48.86%)	0 (0%)

4.2. Physical and cognitive changes

The literature reveals that the ageing population is at higher risk of developing a severe case of COVID-19 [59,60]. Although 66.86% of the participants rated their current level of physical and cognitive health as average, our findings indicate that 57% felt that their post-pandemic health status was worse compared to their pre-pandemic health (see **Figure 5**). Our findings suggest that ageing workers' physical and cognitive health has declined since the pandemic, as predicted by Wister and Speechley [59]. This decline could be attributed to several factors, including reduced access to healthcare services, increased stress levels, and the overall impact of prolonged isolation and reduced physical activity during the lockdowns [8,9,38].

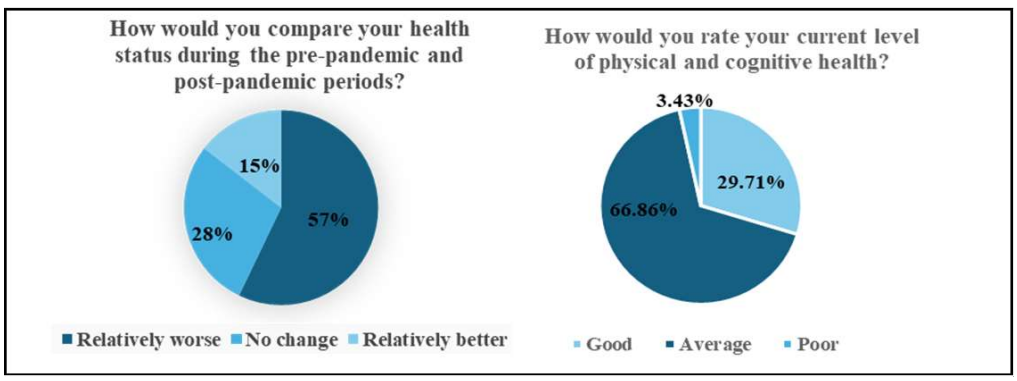

Figure 5. Participants' perceptions of their physical and cognitive health.

Many researchers argue that ageing workers' physical and cognitive health

significantly affects their productivity [7,29,37]. We asked our participants to rate changes in their productivity level from pre-COVID to post-COVID. **Figure 6** shows that 65% of the participants felt they were less productive after the COVID-19 pandemic than they were before it. However, our findings also show that 32.01% of participants felt no change in their productivity level, and 3% felt more productive despite experiencing a decline in their physical and cognitive health. This variation in perceptions of productivity suggests that factors beyond health—for example, changes in roles and responsibilities and workplace accommodations—might be at play.

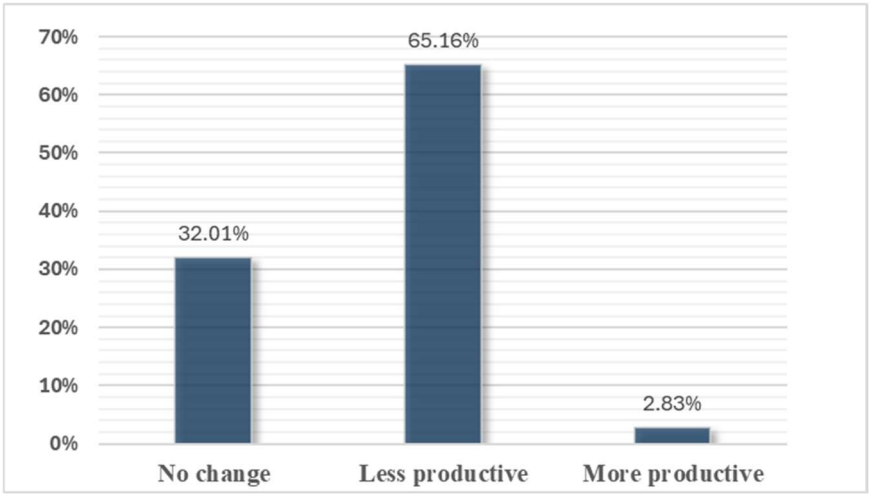

Figure 6. Participants' perceptions of changes in their productivity level during the COVID-19 pandemic.

In addition to the impact of physical and health conditions, researchers have noted that working conditions such as adapting to technological change are expected to influence ageing workers' productivity levels [19,42]. For example, researchers argued that the reliance on technology during the pandemic likely posed a challenge to ageing workers as they tried to adapt to the remote working environment and consequently affected their productivity [19,42].

We therefore asked the participants about their comfort level with technological changes. **Table 2** summarizes the participants' responses to questions about their comfort level with technological change before and after the pandemic: 187 (53.43%) participants felt relatively comfortable with technological changes for office productivity before the COVID-19 pandemic, and 219 (62.57%) felt relatively comfortable with technological changes for office productivity after COVID-19.

Table 2. Comfort and expertise levels with technological changes for productivity.

Item	Neutral	Not comfortable	Relatively comfortable	Very comfortable
How would you rate your comfort and/or expertise with technological changes for productivity before the COVID-19 pandemic?	25 (7.10%)	112 (31.82%)	187 (53.13%)	28 (7.95%)
How would you rate your comfort and/or expertise with technological changes for productivity after the COVID-19 pandemic?	12 (3.41%)	86 (24.43%)	219 (62.22%)	35 (9493%)

The number of respondents who felt very comfortable was low both before and after the pandemic (7.43% and 9.43%, respectively). This finding highlights a critical area for intervention, as improving technological literacy and comfort levels with technology and changes in technology among ageing workers could significantly enhance their productivity and overall job satisfaction.

4.3. Discrimination

Table 3 shows participants' responses to questions about experiences of discrimination. Overall, their responses show that they were experiencing age-related discrimination in the workplace both before and after the COVID-19 pandemic (50.86% and 74%, respectively). Likewise, Pit et al. [8] and Schuster et al. [9], our responses show that age-related discrimination in the workplace increased between the pre-COVID-19 era and the post-COVID-19 era. The participants' responses reflected findings from earlier research conducted by the Nova Scotia Centre on Aging [61]. That study found that older adults seeking work in Nova Scotia face discrimination during candidate selection. This persistent ageism reflects deep-seated biases that underestimate the value and potential contributions of ageing workers and points to a need for more robust anti-discrimination policies and enforcement mechanisms.

Table 3. Participants' responses to discrimination.

Item	Yes	No
Have you experienced discrimination in the workplace due to your age before the COVID-19 pandemic?	181 (51.42%)	171 (48.58%)
Have you experienced discrimination in the workplace due to your age after the COVID-19 pandemic?	217 (61.65%)	135 (38.35%)
Are there accountability mechanisms or redress options for age discrimination in your workplace?	148 (42.05%)	204 (57.95%)

Looking into the accountability measures to redress age discrimination in the workplace, only 125 (35.71%) respondents said such facilities existed in their workplace. This suggests that where policies exist, they are either poorly implemented or not adequately communicated to the employees who need them most. The lack of adequate support structures leaves many older workers vulnerable to age-related biases, with limited options for recourse or redress [34]. Although there is literature [62] that contains policy measures for overcoming age discrimination, the findings from our survey suggest that it is still not entirely solving the ageism issues in the workforce. Previous studies [9] argued that the existing solutions to address age discrimination were ineffective for ageing workers. Our findings corroborate this: 64.29% of participants feel there was no accountability mechanism for age discrimination in their workplace.

4.4. Social and organizational support

Like workers, organizations often struggle to retain their place in the market. They face various challenges, including making sure their business is profitable, adapting to new standards of operation, and managing employees. Many businesses

found it challenging to support their employees during the pandemic, as organizations consist of a wide range of age groups [7,28,63,64]. Since social and organizational support played a vital role in retaining ageing workers during the pandemic, the participants were also questioned about the support their employer provided during this period. **Table 4** shows that 266 (76%) participants stated that the organization they worked for took sufficient measures to prevent COVID-19 infection. The participants' responses indicated that most organizations took sufficient health measures to protect the health of their workers. However, when asked if their management provided special policies/programs to benefit their age group in the workplace both before and after the pandemic, the majority of participants responded that they did not (66% and 84.57%, respectively). These figures suggest no improvement in age-specific support and a significant decline in the perceived organizational support for ageing workers during a critical period. This, in turn, indicates that while organizations may have followed specific health measures listed by the relevant health authority, they did not provide adequate, if any, age-specific support to ageing workers. Our findings align with D'Angelo et al.'s [55] argument, which indicated that while management may meet baseline requirements, the support they provide for the ageing workers is often minimal. In fact, a recent survey conducted by Schellaert and Derous [65] indicates that ageing workers in Belgium expressed no interest in extending their retirement decisions during the pandemic due to the lack of social support at work. An absence of targeted initiatives can lead to increased job insecurity and a higher risk of disengagement among older employees. The gaps in support could have long-term implications, not only for the well-being of older workers but also for the overall retention and productivity of the workforce.

Table 4. Participants' perceptions of levels of organizational support.

Item	Yes	No
Are there sufficient health measures undertaken by your workplace to prevent COVID-19 infection?	266 (75.57%)	86 (24.43%)
Does your management provide special policies/programs to benefit your age group in the workplace before the COVID-19 pandemic?	119 (33.81%)	233 (66.19%)
Are there additional support mechanisms after the COVID-19 pandemic?	56 (15.91%)	296 (84.09%)

5. Conclusion

An ageing population and labour shortages are significant and growing challenges in Canada. Policymakers have traditionally addressed these issues by increasing immigration, identifying strategies to retain older workers, and adopting innovative technologies [66]. However, the COVID-19 pandemic underscored the need for significant policy reforms to mitigate the impact of population ageing on national productivity. Although encouraging older workers to remain in or return to the workforce is often seen as complex, it is increasingly viewed as a more sustainable solution compared to relying solely on immigrant labour [66,67].

While factors such as health, technological change, age discrimination, and organizational support are widely cited as influences on older workers' participation, limited empirical research focused specifically on Canadian ageing workers provides

little direct evidence to support these assumptions [10]. In contrast, recent studies suggest that pandemic-driven shifts toward remote and hybrid work have helped reduce barriers, offering older workers more flexibility to remain employed [16,60].

Our survey findings also challenge prevailing assumptions about these influencing factors. Contrary to the literature that characterizes older adults as less technologically proficient [16,39,41,68], most participants in our study reported being relatively comfortable with technological tools. Moreover, the proportion of respondents who felt confident in technology increased after COVID-19. This growing adaptability is a promising sign for the continued participation of older workers. Nonetheless, significant challenges remain, particularly around job displacement, skill mismatches, and access to age-friendly employment opportunities [17,18].

Given the scarcity of empirical research focused on Canadian ageing workers, it is essential to conduct further studies to understand their unique experiences—especially in the post-pandemic context. Future research should investigate how factors such as age-related health disparities, digital transformation, and workplace policies affect the resilience of older workers across various sectors, with particular attention to gender and immigrant status [17].

Finally, the results of this research aim to provide an impetus to employers and policymakers, through quantitative evidence, to implement targeted policies and programs to support ageing workers' continued participation in the labour market. Key recommendations include prioritizing digital literacy and technology support tailored to this demographic, strengthening and effectively communicating anti-discrimination policies to foster inclusive workplaces, and implementing targeted health and social initiatives—especially during crises such as the COVID-19 pandemic—to enhance worker retention and well-being.

6. Study limitations and directions for future research

The authors acknowledge several limitations of this study. First, the use of convenience and snowball sampling introduces selection bias, as respondents may differ from the broader population of ageing workers. However, this approach was purposefully chosen by the authors to protect participant privacy and employment status, given the sensitivity of the research topic. Second, reliance on an online survey may have excluded workers in less technology-intensive sectors (e.g., manufacturing) and those with limited digital literacy or internet access, potentially skewing the sample toward more technologically adept individuals. To address these limitations, follow-up interviews and supplementary methods may be conducted under strict ethical protocols to validate findings while preserving confidentiality. Third, while social desirability bias may affect responses to sensitive questions, the anonymous survey design aimed to reduce apprehension and encourage candid responses. Finally, the findings are context-specific and not intended for direct application beyond Canada. National differences in employment standards, retirement systems, healthcare access, and social policies may limit the broader applicability of the results. All in all, to manage these limitations and strengthen qualitative credibility, the authors engaged in collaborative, iterative analysis of open-ended responses to employ a thematic analysis approach, enhancing interpretive trustworthiness despite the absence of

formal reliability testing.

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Informed consent statement: The online survey was conducted anonymously, and the consent form was built into the Qualtrics survey. The participants were asked to respond to the consent form before responding to the survey. In the informed consent form, participants were informed that they were participating in the anonymous survey and providing consent to publish their responses.

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

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Article

Unmasking wealth flows, fertility, and parental engagement of children in labor in the Ashanti region of Ghana

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Abstract: Background: In high-fertility contexts, evidence suggests that children produce more than they consume and therefore provide net wealth to parents. **Objective:** Based on this, the study attempts to examine whether wealth flows in families and fertility influence parents to engage their children in labor in the Ashanti Region of Ghana. **Methods:** A cross-sectional descriptive study design with a four multistage sampling technique was used for the study. Primary data were collected from 682 respondents through structured questionnaires administered in the field and were processed with SPSS version 27. Frequency distribution, chi-squared test, and binary logistic regression were used to summarize the data. The binary logistic regression was used to assess the influences of the IVs on the DV. **Results:** The majority of parents (75.0%) engaged their children in labor. Parents who believe that children should contribute financially to the household income had increased odds of engaging children in child labor. Parents who endorsed that they would stop a child from working when financial support is readily available, parents who do not know whether they would stop a child from working when financial support is readily available, and fertility were associated with decreased child labor. **Conclusion:** The findings underscore the need for a multifaceted response to child labor that goes beyond legal prohibition alone. Strengthening and enforcing existing legal frameworks, raising public awareness of the long-term consequences of child labor, and expanding social protection mechanisms to support vulnerable households are essential.

Keywords: children; engage; families; fertility; labor; parents; unmasking; wealth flows

1. Introduction

Today, nearly 1 in 10 children worldwide are engaged in labor that denies them their basic human rights and jeopardizes their well-being [1–6]. Globally, estimates indicate that approximately 160 million children have been forced into child labor since 2020 [7–9]. Among these children, 63 million are girls, and 97 million are boys, and about half (79 million) are engaged in hazardous work highlighting that for every three children in child labor, one is out of school [8]. Roughly, 70% (112 million) of these children work in agriculture including farming, and livestock herding [8,10].

It has been established that globally, sub-Saharan Africa, has the highest (86.6 million) number of children in labor, followed by Central and Southern Asia with 26.3 million [11,12] of which Ghana is not exempted, and this is evident that the child labor prevalence of Ghana stands at about 22% of the childhood population [4]. Additionally, over 1.1 million children age between 5 and 17 years are engaged in some form of work, representing 10% of all the children in this age group [13,14]. Almost 900,000 of these children are involved in a paid labor [15,16], about half

(458,443) are not attending school, more than sixty thousand (68,500) never attended school, and those that attended school in the past are about four hundred thousand (389,943) [15,16]. Further, among the children, more than half (56%) are males [13].

Geographically, the evidence estimated a complex geographical picture. For instance, urban areas accounted for over a quarter (309,199; 28%) of all the working children, while rural areas had the higher proportions, with almost three-quarters (795,175; 72%) [14–16]. From a regional perspective, Ashanti (13.6%) accounts for the highest percentage of children working, followed by Bono East (12.1%), and then Northern (11.8%) [15–17]. No matter where or how it occurs, child labor restricts children from their most fundamental rights [9,18,19].

John Caldwell's wealth flows theory proposes a direct link between fertility and prosperity [20]. In "primitive" and "traditional" societies with net upward wealth flows, the economically rational decision is to have as many surviving children as possible because each additional child adds positively to a parent's wealth, security in old age, and social and political well-being [21]. This theory suggests that in high-fertility contexts, children produce more than they consume and therefore provide net wealth to parents [21–23]. However, empirical tests of this hypothesis have not found evidence to show that children are net providers to parents in high-fertility contexts [21,23–29]. Based on this assertion, the current study attempts to examine how wealth flows in families and fertility influence parents to engage their children in labor in the Ashanti Region of Ghana.

Specifically, the study seeks to: analyze if wealth flows in families influence parents to engage their children in labor in the Ashanti Region of Ghana; and ascertain whether fertility influences parents to engage their children in labor in the Ashanti Region of Ghana.

The study further hypothesized that there is no statistically significant relationship between wealth flows in families, fertility, and parental engagement of children in labor in the Ashanti Region of Ghana.

2. Methods

2.1. Study area and population

Ashanti Region provides an appropriate context for this study due to its prevalence (14%) of children engagement in labor in Ghana [15–17]. Further, the region was chosen based on its substantial role in the cocoa industry, and small-scale mining due to poverty, inadequate educational opportunities, and cultural norms. Furthermore, while cocoa production is vital to the region's economy, it also depends largely on children as laborers, with children performing hazardous tasks [4]. The Region has a population of 5,440,463 in 2021 of Ghana's total population and a total household of 1,523,101 which refers to a person or a group of two or more persons (related or unrelated) who live together, share housekeeping arrangements (eating and sleeping), and recognize one person as the head [30]. The population of interest in the study is 1,523,101 households in the region.

2.2. Research design and data source

A cross-sectional descriptive study design was utilized for the study. The design was adopted because it aims at describing generalized relationships between distinct elements and conditions. Furthermore, it allows data to be collected at once and as well permit multiple variables to be assessed simultaneously [31–33]. Primary data were collected from 682 respondents through structured questionnaires administered in the field.

2.3. Sample and sampling procedure

A sample of 682 respondents was recruited for the study with the help of Cochran's [34] sample size formula for estimating sample size. With the help of this formula, sample size was estimated at 310 as follows:

$$n = \frac{z^2 \times p \times (1-p)}{d^2}$$

n = sample size

Confidence level set at 95% (1.96)

The p-value set at 0.05.

z = standard normal deviation set at 1.96

d = degree of accuracy desired at 0.05

p = proportion of households was 28%. This was obtained by dividing total households by the population in the region which is 1,523,101 by 5,440,463 gives 0.28. Mathematically, 1,523,101/5,440,463 = 0.28.

$$n = \frac{1.96^2 \times 0.28 \times (1-0.28)}{0.05^2}$$

= 309.7866 approximately 310. After the calculation, the sample size was 310. Assuming 10% non-response rate, design effect of 2, (to compensate the design effect) the sample size is: $N = 310 \times 2 + 10\% \; of \; 620 = 620 + 62 = 682$. The estimated sample for the study is 682.

A multistage sampling technique was employed. The first stage was the grouping of the districts into strata. With the strata, we used urban and rural classifications where urban served as stratum 1 and rural as stratum 2. The second stage was the selection of 4 districts two (2) each from each stratum to serve as the study site. The selected districts were Offinso North, Bosome Freho, Kumasi Metropolitan, and Ahafo Ano North Municipal. The third stage was proportional allocation / equal allocation (25%) to the stratum. This was done equally since a specific data regarding districts with high prevalence of child labor is not readily available in the region. The stage four was where a systematic sampling technique was used to reach the participants. The method was used because it allows respondents to be selected from a population at regular intervals after a random starting point thereby ensuring an even distribution and reducing potential bias.

In the first study site (Bosome Freho) we calculated the regular interval by dividing the population of the district (62, 259) [30] by the sample needed for the study which is 62259/682 = 91.28 approximately 91. Based on the proportion obtained, numbers between 1 to 91 were generated. Out of these numbers, number 15 was

selected to represent the first house for the study. So, starting from Bosome Freho police station and following a *serpentine order* the fifteenth house was selected, and in that house, an eligible household head present and willing to participate in the study was randomly selected to represent the first respondent for the study followed by 15 + 91 = 106th, followed by 15 + 106 = 121st, followed by 15 + 121 = 136th and so on and so forth. However, in each selected house, only one interview was conducted. A house selected with no eligible respondent, the procedure was repeated by starting from an identical feature or landmark till all the sample needed was obtained. This procedure was used in the rest (Offinso North, Kumasi Metropolitan, and Ahafo Ano North Municipal) of the study sites to reach the respondents.

2.4. Inclusion and exclusion criteria

To be eligible for inclusion in the study, respondents were required to be parents aged 27 years or older, resident in the selected study sites, have at least a child with age limit of 5, be present at the selected study sites as of the time of the study, and be willing to participate in the study. The study excluded parents who did not meet the above criteria.

2.5. Variables and measurements

The Independent Variables (IVs) in the study are wealth flow and fertility [20,21,35,36]. Wealth flow has (family income and expenditure, wealth flow & resource distribution, and perceptions and social dynamics) as indicators while fertility has (number of children born, and children desire) as indicators [37,38]. The Dependent Variable (DV) is child labor. For the purposes of Sustainable Development Goals (SDG) reporting, two indicators are used for measuring child labor, the first is based on the production boundary set by the United Nations System of National Accounts (SNA) and the second is based on the general production boundary. They are as follows: Indicator 1: Proportion and number of children aged 5–17 years engaged in economic activities at or above age-specific hourly thresholds (SNA production boundary basis), which includes: (a) children aged 5–11 working at least 1 hour per week in economic activity; (b) children aged 12–14 working for at least 14 hours per week in economic activity; and (c) children aged 15–17 working for more than 43 hours per week in economic activity. Indicator 2: Proportion and number of children aged 5–17 years engaged in economic activities and household chores at or above age-specific hourly thresholds (general production boundary basis), which includes: (a) children aged 5–11 working at least 1 h per week in economic activity and/or involved in unpaid household services for more than 21 h per week; (b) children aged 12–14 working for at least 14 h per week in economic activity and/or involved in unpaid household services for more than 21 h per week; and (c) children aged 15–17 working for more than 43 h per week in economic activity [39–41].

However, in Ghana, the minimum labor requirements for age 5-12 is “no work”, 13–14 is “light work (not to exceed 2 hours during the school day and not exceed 3 hours outside the school day)” while age 15–17 is either “medium work (<18 h per week)” (be fewer than 3 h each day on school days if enrolled in school) or “full-time work (<43 h per week)” for those not enrolled in school. It is inappropriate for children

<18 years of age to engage in risky labor [42–46]. In this study, the SDG indicators were used to measure child labor. Altogether, *indicator 1* and *indicator 2* items sum up to give six (6) items. For easy reporting, the items were assigned yes or no, so, parents that responded in the affirmative to three (3) or more of the six (6) items were considered to have engaged a child in labor.

2.6. Data collection procedure

Data collection commenced on 15th January, 2025 and ended on 5th February, 2025 with the help of five research assistants. In all, 18 days were used to collect the data. In the field, research assistants were assisted with computer tablets to collect the data. Primary data were collected from 682 respondents through structured questionnaires administered in the field. The questionnaire used to gather the data was developed from previous standardized survey instruments and the literature.

2.7. Data processing and analysis

Data were processed with SPSS version 27 and analyzed with frequency distribution, Pearson's chi-squared test of independence and binary logistic regression. The frequency distribution was used to summarize respondents' responses into proportions. The Pearson's chi-squared test of independence was used to test the hypotheses postulated in the study, either to accept or reject the null hypotheses. Statistical significance was primarily assessed at the 5% level ($p < 0.05$), with additional reference to the 1% ($p < 0.01$) and 10% ($p < 0.10$) levels where appropriate. The binary logistic regression was also used to assess the influences of the IVs on the DV. With the binary logistic regression analysis, we employed the "Enter" method, and *p*-value of 0.05 was considered as significant.

2.8. Ethical consideration

Though the study did not seek ethical reviewed approval but ethical practices were adhered to in the field. Particularly, respondents were told that information they will provide will be kept confidential and will strictly be used for academic purposes thus adding to academic literature and that no any third party would have access to the information. With anonymity, anything that could identify a respondent to a data was devoid. On privacy, respondents were allowed to choose the befitting place they deemed appropriate for the study themselves. To climax it, an oral consent was sought from them before participation and they were told that participation is voluntary, and that they can withdraw from the study anytime they feel uncomfortable. They were told to feel free without any coercion to decide either to participate or not. So, those willingly owned out to take part were giving the opportunity to be part of the sample.

3. Results

The study comprised 44% males and 56% females. Whereas 37.9% belong to 50–59 age group, 12.6% were in the 27–29 age group. Nearly 44% had secondary school education while 6.5% had post-secondary education. Half of the sample had only one member who earns income for the family while 19% had 2 earning members. Half of the sample were urban dwellers (see **Table 1**).

Table 1. Sociodemographic characteristics of respondents.

Variable	Frequency	Percentage
Sex		
Male	298	43.8
Female	382	56.2
Age in group		
27-29	86	12.6
30-39	126	18.5
40-49	210	30.9
50-59	258	37.9
Level of Education		
No education	126	18.5
Basic	212	31.2
Secondary	298	43.8
Higher	44	6.5
Number of earning members in the family		
1	340	50.0
2	130	19.1
2+	210	30.9
Place of residence		
Urban	340	50.0
Rural	340	50.0
Total	**680**	**100.0**

Source: Fieldwork (2025).

In pursuit of ascertaining the proportion of parents who engage children in labor, prompted us to adopt The SDGs indicators for measurement. The SDGs have two indicators for measuring child labor, the first is based on the production boundary set by the SNA and the second is based on the general production boundary. They are as follows: Indicator 1: Proportion and number of children aged 5–17 years engaged in economic activities at or above age-specific hourly thresholds (SNA production boundary basis), which includes: (a) children aged 5–11 working at least 1 hour per week in economic activity; (b) children aged 12–14 working for at least 14 hours per week in economic activity; and (c) children aged 15–17 working for more than 43 hours per week in economic activity. Indicator 2: Proportion and number of children aged 5–17 years engaged in economic activities and household chores at or above age-specific hourly thresholds (general production boundary basis), which includes: (a) children aged 5–11 working at least 1 hour per week in economic activity and/or involved in unpaid household services for more than 21 hours per week; (b) children aged 12–14 working for at least 14 hours per week in economic activity and/or involved in unpaid household services for more than 21 hours per week; and (c) children aged 15–17 working for more than 43 hours per week in economic activity [40–42]. Altogether, indicator 1 and indicator 2 items sum up to give six (6) questions. So, for easy reporting, the items were assigned *yes or no*, so, parents that responded in

the affirmative to three (3) or more of the six (6) questions were considered to have engaged a child in labor. After analysis, the results revealed that 510 (75%) of the participants engage children in labor while 170 (25.0%) do not.

Table 2. Wealth flows in families.

Variable	Frequency	Percentage
Most contributor to household income		
Father	382	56.2
Mother	130	19.1
Children	168	24.7
Household's average monthly income		
GHS<1000	298	43.8
GHS1000–1999	86	12.6
GHS2000–2999	126	18.5
GHS3000–3999	170	25.0
Controller of household spending decisions		
Father	298	43.8
Mother	126	18.5
Elder child	168	24.7
Both parents and children	88	12.9
Should children contribute financially to the household		
No	170	25.0
Yes	510	75.0
Amount of money, a child contributes towards family expenses in a month		
GHS1000	384	56.5
GHS1500	86	12.6
GHS2000+	210	30.9
Purpose of child's financial contribution		
Education of siblings	84	12.4
Household food and rent	298	43.8
Health expenses of elders	212	31.2
Savings/loans repayment	86	12.6
Would stop child from working when financial support is readily available		
No	300	44.1
Yes	168	24.7
Do not know	212	31.2
Children are respected when they contribute to family income		
More respected	170	25.0
Less respected	340	50.0
No change	170	25.0
Experienced any changes in the pattern of resource flow over generations		
No	170	25.0
Yes	510	75.0
Total	**680**	**100.0**

Source: Fieldwork (2025).

To answer research objective one which is "analyze if wealth flows in families influence parents to engage their children in labor in the Ashanti Region of Ghana" made us asked questions spanning from "income contributors, monthly income, spending decisions maker, children mandated to contribute to family income, child contribution percentage, child's income contribution purpose, stop child from work when financial support is readily available, children are respected when they contribute to family income, and pattern of resource flow." The results are presented in **Table 2**.

Regarding the most contributor to household income, the results revealed that 56.2% of the participants reported fathers while 19.1% indicated mothers (see Table 2). Nearly 44% reported that their household's average income is <GHS 1000 while 12.6% said it ranges from GHS 1000-to-1999 (see **Table 2**). Concerning the controller of the household spending decisions, the results revealed that more than forty per cent (43.8%) indicated fathers, while 12.9% reported that it is both parents and children (see **Table 2**).

When asked whether children should contribute financially to the household income or not, the results revealed that 75% of the participants answered in the affirmative (see **Table 2**). Regarding the amount of money children contribute towards family expenses in a month, the results revealed that more than half of the sample reported GHS 1000, while 12.6% indicated GHS 1500 (see **Table 2**).

When asked about the purpose of child's income contribution in the family, the results revealed that a little above forty-three per cent (43.8%) reported provision of food and rent, while 12.4% indicated education of siblings (see **Table 2**). When participants were asked if they would stop children from working when financial support is readily available or not, the results revealed that 44.1% indicated that they would not stop the children from work, while 24.7% said they would stop the children from work (see **Table 2**).

When participants were asked to indicate whether children are respected or not, when they contribute to family income, the results revealed that 50.0% indicated children are less respected, while 25.0% reported it does not change anything about the children (see **Table 2**). Whereas 75.0% of participants reported that family has experienced changes in the pattern of resource flow over generations, 25.0% said family has not experienced changes in the pattern of resource flow over generations (see **Table 2**).

Among the 510 participants who indicated family has experienced changes in the pattern of resource flow over generations were further asked to indicate the pattern of flow, the results found revealed that 56% of them indicated downward wealth flow, while 19% reported upward wealth flow.

Table 3 has Pearson's chi-squared test of independence on wealth flow in families and parents' engagement of children in labor. This analysis was conducted to test the hypothesis that there is no statistically significant relationship between wealth flows in families and parental engagement of children in labor. Statistically significant relationships were found in almost all the variables studied under wealth flow in families namely: Most contributor to household income [$\chi^2 = 157.387$, $p < 0.001$], household's average monthly income [$\chi^2 = 75.018$, $p < 0.001$], controller of household spending decisions [$\chi^2 = 162.649$, $p < 0.001$], children should contribute financially

Table 3. Relationship between wealth flows in families and parental engagement of children in labor.

Variable	No (%)	Yes (%)	Total *n* (%)	χ^2	*P*-value
Most contributor to household income				157.387	<0.001
Father	42(11.0)	340(89.0)	382(100.0)		
Mother	86(66.2)	44(33.8)	130(100.0)		
Children	42(25.0)	126(75.0)	168(100.0)		
Household's average monthly income				**75.018**	**<0.001**
GHS<1000	84(28.2)	214(71.8)	298(100.0)		
GHS1000–1999	44(51.2)	42(48.8)	86(100.0)		
GHS2000–2999	0(0.0)	126(100.0)	126(100.0)		
GHS3000–3999	42(24.7)	128(75.3)	170(100.0)		
Controller of the household spending decisions				162.649	<0.001
Father	44(14.8)	254(85.2)	298(100.0)		
Mother	84(66.7)	42(33.3)	126(100.0)		
Elder child	42(25.0)	126(75.0)	168(100.0)		
Both parents and children	0(0.0)	88(100.0)	88(100.0)		
A child should contribute financially to household income				79.158	<0.001
No	86(50.6)	84(49.4)	170(100.0)		
Yes	84(16.5(	426(83.5)	510(100.0)		
Amount of money a child contributes towards family expenses				296.595	<0.001
GHS1000	0(0.0)	384(100.0)	384(100.0)		
GHS1500	44(51.2)	42(48.8)	86(100.0)		
GHS2000+	126(60.0)	84(40.0)	210(100.0)		
Purpose of a child's income contribution to the family				102.475	<0.001
Education of siblings	0(0.0)	84(100.0)	84(100.0)		
Household food and rent	42(14.1)	256(85.9)	298(100.0)		
Health expenses of elders	84(39.6)	128(60.4)	212(100.0)		
Savings/loans repayment	44(51.2)	42(48.8)	86(100.0)		
Would stop a child from working when financial support is readily available				**46.756**	**<0.001**
No	42(14.0)	258(86.0)	300(100.0)		
Yes	42(25.0)	126(75.0)	168(100.0)		
Don't know	86(40.6)	126(59.4)	212(100.0)		
A child is respected when he or she contributes to family income				0.031	0.984
More respected	42(24.7)	128(75.3)	170(100.0)		
Less respected	86(25.3)	254(74.7)	340(100.0)		
No change	42(24.7)	128(75.3)	170(100.0)		
Family has experienced changes in the pattern of resource flow over generations				75.556	<0.001
No	0(0.0)	170(100.0)	170(100.0)		
Yes	170(33.3)	340(66.7)	510(100.0)		

Note: Row percentages in parenthesis, Chi-square significant at (0.001), (0.05), (0.10)
No: do not engage child in labor Yes: engage child in labor
Source: Fieldwork (2025).

to the household income [$\chi^2 = 79.153$, $p < 0.001$], amount of money a child contributes towards family expenses [$\chi^2 = 296.595$, $p < 0.001$], purpose of a child's income contribution in the family [$\chi^2 = 102.475$, $p < 0.001$], would stop a child from working when financial support is readily available [$\chi^2 = 46.756$, $p < 0.001$] as well as family has experienced changes in the pattern of resource flow over generations [$\chi^2 = 75.556$, $p < 0.001$] and parental engagement of children in labor. However, statistically significant relationship was not found in children are respected when they contribute to family income [$\chi^2 = 0.031$, $p = 0.984$] and parental engagement of children in labor.

Table 4 has binary logistic regression results on wealth flows in families and parents' engagement of children in labor. This analysis was conducted on nine (9) items (income contributors, monthly income, spending decisions maker, children mandated to contribute to family income, child contribution percentage, child income generation purpose, stop child from work when financial support is readily available, children are respected when they contribute to family income, and pattern of resource flow) to ascertain the influences each of them exerts on parents' engagement of children in labour.

Table 4. Binary logistic regression results on wealth flows in families and parental engagement of children in labor.

Variable	B	Wald	Sig.	Exp(B)	95CI	
Children should contribute financially to the household income (No = 1.0)						
Yes	1.428	50.381	0.000	4.172	2.812	6.189
Would stop a child from working when financial support is readily available (No = 1.0)						
Yes	−0.568	5.010	0.025	0.567	0.345	0.932
Don't know	−1.111	23.482	0.000	0.329	0.210	0.516
Constant	**0.682**	**9.191**	**0.002**	**1.977**		

Source: Fieldwork (2025). Significant at 0.05.

After processing the data, only two variables (children should contribute financially to the household income, and would stop a child from working when financial support is readily available) were significant. Those that were not significant were removed from the model (see **Table 4**). Overall, the logistic regression model was significant at -2LogL = 667.883; Nagelkerke R^2 of 0.197; $\chi^2 = 96.893$; $p < 0.001$ with correct prediction rate of 75.3%. More importantly, the Model Summary which shows a Nagelkerke R^2 of 0.197 suggests that the model explains 19.7% of variance in the likelihood of parents engaging their children in labor in the Ashanti Region of Ghana. With this percentage contribution to the entire model, the results confirmed the whole model significantly predict parental engagement of children in labor in the Ashanti Region of Ghana.

Table 4 revealed that parents who believe that children should contribute financially to the household income was significantly related to child labor at $p <$ 0.001, (OR = 4.172, 95%CI ([2.812–6.189]). This variable identifies those parents to have 4.2 times more likely to engage their children in labor compared with their counterparts that reported they do not believe that a child should contribute financially to the household income (see **Table 4**). Further, parents who endorsed that they would stop a child from working when financial support is readily available was statistically

significant related to child labor at $p = 0.025$, (OR = 0.567, 95%CI ([0.345–0.932]). This factor labels those parents to have 0.6 times less likely to engage their children in labor compared with their counterparts that intimated they would not stop a child from working when financial support is readily available (see **Table 4**). Furthermore, parents who do not know whether they would stop a child from working when financial support is readily available was significant at $p < 0.001$, (OR = 0.329, 95%CI ([0.210–0.516]). This variable revealed those parents to have 0.3 times less likely to engage their children in labor compared with their counterparts that reported they would not stop a child from working when financial support is readily available (see **Table 4**).

In an attempt to answer research objective two which is "ascertain whether fertility influences parents to engage children in labor in the Ashanti Region of Ghana" ignited questions ranging from "number of children born, children desire, and many children increases the likelihood of child labor." The results are presented in **Table 5**.

Table 5. Fertility in the Ashanti Region.

Variable	Frequency	Percentage
Number of children		
3	424	62.4
1	130	19.1
4	84	12.4
5+	42	6.2
Number of children desire		
5	384	56.5
4	227	33.4
6	69	10.1
Having many children increases the likelihood of child labor		
No	468	68.8
Yes	84	12.4
Not sure	128	18.8
Total	**680**	**100.0**

Source: Fieldwork (2025).

With respect to the number of children parents have, the results revealed that 63.4% of parents have 3 children, while 6.2% have more than 5 children (see **Table 5**). Whereas 57% of parents desire 5 children, 10% desire 6 children. On whether having many children increases the likelihood of child labor or not, the results revealed that 69% of parents reported that it cannot while 12% indicated that it can (see **Table 5**).

Further analysis was run with Pearson's chi-squared test of independence to determine whether relationship exists between fertility and parental engagement of children in labor. This analysis was substantial to test the hypothesis that there is no statistically significant relationship between fertility and parental engagement of children in labor. Statistically significant relationships were found in all the variables namely: number of children [$\chi^2 = 165.514$, $p < 0.001$], number of children desire [χ^2

= 42.334, $p < 0.001$] as well as having many children increases the likelihood of child labor [$\chi^2 = 33.546$, $p < 0.001$] and parental engagement of children in labor (see **Table 6**).

Table 6. Relationship between fertility and parental engagement of children in labor.

Variable	No (%)	Yes (%)	Total *n* (%)	χ^2	*P*-value
Number of children				165.514	<0.001
3	84(19.8)	340(80.2)	424(100.0)		
1	44(33.8)	86(66.2)	130(100.0)		
4	0(0.0)	84(100.0)	84(100.0)		
5+	42(100.0)	0(0.0)	42(100.0)		
Number of children desire				42.334	<0.001
5	128(33.3)	256(66.7)	384(100.0)		
4	42(18.5)	85(81.5)	227(100.0)		
6	0(0.0)	69(100.0)	69(100.0)		
Having many children increases the likelihood of child labor				33.546	<0.001
No	128(27.4)	340(72.6)	468(100.0)		
Yes	0(0.0)	84(100.0)	84(100.0)		
Not sure	42(32.8)	86(67.2)	128(100.0)		

Note: Row percentages in parenthesis, Chi-square significant at (0.001), (0.05), (0.10)
No: do not engage child in labor Yes: engage child in labor
Source: Fieldwork (2025).

Table 7. Binary logistic regression results on fertility and parents' engagement of children in labor.

Variable	B	Wald	Sig.	Exp(B)	95CI	
Number of children (3 = 1.0)						
1	−1.619	35.427	0.000	0.198	0.116	0.338
4	19.584	0.000	0.996	320046902.829	0.000	0.000
5+	−22.822	0.000	0.997	0.000	0.000	0.000
Having many children increases the likelihood of child labor (No = 1.0)						
Yes	20.601	0.000	0.996	884737793.590	0.000	0.000
Not sure	−0.902	12.726	0.000	0.406	0.247	0.666
Constant	**1.619**	**91.876**	**0.000**	**5.048**		

Source: Fieldwork (2025). Significant at 0.05.

Table 7 has binary logistic regression results on fertility and parents' engagement of children in labor. This analysis was conducted on three (3) variables (number of children, number of children desire, and having many children increases the likelihood of child labor) just to unravel the effect each of them has on parents' engagement of children in labor.

After processing the data, only two variables (number of children, and having many children increases the likelihood of child labor) were significant. Therefore, the variable that was not significant was removed from the model (see **Table 7**). Overall, the logistic regression model was significant at -2LogL = 511.811; Nagelkerke R^2 of 0.460; $\chi^2 = 252.965$; $p < 0.001$ with correct prediction rate of 81.2%. More

importantly, the Model Summary which shows a Nagelkerke R^2 of 0.460 suggests that the model explains 46% of variance in the likelihood of parents engaging children in labor in the Ashanti Region of Ghana. With this percentage contribution to the entire model, the results confirmed the whole model significantly predict parents' engagement of children in labor in the Ashanti Region of Ghana.

It emerged in **Table 7** that parents who had just a child (one) was significantly related to child labour at $p < 0.001$, (OR = 0.198, 95%CI ([0.116–0.338]). This indicator categorizes those parents to have 0.2 times less likely to engage their children in labor compared with their counterparts that reported that they have three (3) children (see **Table 7**). Further, parents who were not sure whether having many children increases the likelihood of child labor was statistically significant related to child labor at $p < 0.001$, (OR = 0.406, 95%CI ([0.247–0.666]). This factor tags those parents to have 0.4 times less likely to engage their children in labor compared with their counterparts that intimated having many children will not increase the likelihood of child labor (see Table 7). However, the "number of children desire" was not significant which could be as a result of chance.

4. Discussion

The study attempted to unmask whether wealth flows in families and fertility influence parents to engage their children in labor. In this regard, the analysis of wealth flows in families revealed that fathers (56.2%) are the most contributor to household income. Providing finances in families has been a key aspect of fathering through the ages making them the principal income contributors in the family. This finding corroborated with previous studies conducted in America, and Nigeria [47,48] respectively which also found that fathers still tend to be seen as the "breadwinners" of the family, while mothers routinely take on most of the childcare [47,48]. On the other hand, some significant proportion of the participants (24.7%) reported children as the most contributor of household's income. The reason for this finding could be that these participants have realized that breadwinners of those households were struggling to make ends meet and are experiencing hunger making them desperate which invariably led them to rely on income from child labor to cover basic needs like food. Though it is uncommon for children to be the primary income source for a household but they can contribute significantly, especially in low-income households. Children can contribute through various means, including paid work, unpaid work like household chores, or even by simply being able to reduce the net cost of rearing them, thus increasing the demand for more children. This finding agrees with previous studies conducted in Southeast Asia, and Canada, UK, and US [49,50] respectively which also found that children often take on the role of family "breadwinner," providing financial support and sharing family responsibilities [49,50]. However, the 19.1% participants who indicated that mothers were the most contributor of household's income reason could be that they have witnessed that most mothers make a major contribution to their family's household budget. This finding corroborated with previous studies, which found that one third of British working mothers are main breadwinners [51,52].

In terms of households' income, a varied average income for households were

found stemming from GHS <1000 (43.8%), GHS 1000-1999 (12.6%), GHS 2000–2999 (18.5%) while 25.0% earn GHS 3000-3999. This finding signifies that households' income is often prone to significant seasonal variations especially in the rural areas where people's income is determined by the sale of their harvest and seasonal employment. This finding corroborated with previous study which found that household annual income was distributed as follows: 35% reported ≤$45,000; 30% reported $50,000 to ≤$95,000; and 35% reported ≥$100,000 [53].

Fathers were noted to be the most controller of household's spending decisions, indicating that in many cultures, traditional gender roles have led fathers to be seen as the primary financial providers, and therefore, the primary decision-makers regarding household spending. This finding is in line with a study which found that traditionally, fathers are expected to contribute financially to the family [54]. However, the participants that reported both parents and children reason could be that they have realized that children in this modern era are the major influencing factor that impacts parents' purchasing habits and influences their decision-making. This finding agrees with a previous study, which found that parents and children adopt a range of negotiation or bargaining tactics for resource allocation and enhanced family value [55].

Children were found to be financial contributors to household income. This finding suggests that involving children in discussions about household finances and allowing them to contribute in small ways can be beneficial for their financial literacy and responsibility. Hence, giving them pocket money and discussing family finances with them can enable them understand the concept of budgeting and saving. This finding corroborated with a previous study which found that children who sold for their families, earned between GH$7 and GH$15 per day to support household income [56].

However, the proportion that refuted the idea that children should contribute financially to household income reason could be that they see children as minors, and that their primary focus should be on their education and development. Parents with this idea in mind, no matter how poorly they are paid, they will always prefer to send their children to school and borrow against their future earnings, rather than to send children to work. This finding corroborated with a previous study which found that if children are begging, the blame is put squarely on their parents because they can stop them from engaging in it, if they so desire [57]. On the contrary, the finding disagreed with a study which found that despite the passage of new laws and policies to curb child labor, parents still engage their children in work [58].

Most parents declared that they would not stop children from working even if financial support is readily available. The reason for this finding could be that those parents consider child labor as normal, and that sometimes they presume it is good for children to work for their own survival, and that of their family. This finding is in line with previous studies which found that in a poor economy, even if overall household income rose on balance, the rise would not be sufficient to make parents happy with not sending children to work [59,60]. However, the proportion that reported they would stop children from working when financial support is readily available reason could be that they are aware that in the short run, putting children to work may increase immediate household income and in the long run hinders their long-term human

capital development, which might invariably reduce future family income and overall economic well-being. Hence, child labor often interferes with child's access to education and the necessary skills development thereby impacting their future income earning potentials. This finding agrees with a previous study, which found that cash transfers are a popular and successful means of tackling household vulnerability and promoting human capital investment. Further, the study stressed that they can help reduce child labor, especially when it is a response to household vulnerability, but their efficacy is very variable [61].

It emerged that children that contribute to family income, some are less respected, others are more respected while some too their financial contribution to family income does not attract any change to their person. Generally, children who contribute financially to the family income are often respected more by their families. But a situation whereby the financial contribution of the child does not make any difference in the household financial budget, it might not attract any form of respect from the parents compared with those that their contribution makes an essential impact on the household financial budget. This outcome confirmed previous studies that "decisions undermine respect" "part of culture to work" "we have to contribute to family income" "children are cheap labor" and "cocoa and fishing are family work" [62,63].

A significant proportion of the participants submitted that they had experienced changes in the pattern of resource flow over generations in the family. The reason for this finding could be that initially these participants were enjoying resource flow upwards thus from children to parents. Meaning children hustle to provide money to support their family but now it could be that it is no longer the case rather it flows from parents to children (downwards flow). Meaning parents bear all expenses of children in the family. Further, it could be that these participants have observed that there has been a shift in who provides resources in the family. This outcome corroborated with previous studies which found that there have been fundamental changes in the intergenerational family, and yet families continue to be an important part of people's lives [64-66]. However, those who reported they have not experienced any changes in the pattern of resource flow over generations reason could be that there has not been any shift in who controls and provides resources in the family. This finding refuted a study which found that changes in the intergenerational family relationships are typically seen through the prism of contemporary parents supporting their children all along [67].

The study found that relationship exists between wealth flows in the families and parents' engagement of children in labor. Therefore, the null hypothesis was rejected. A p-value of <0.001 found in all the variables (most contributor to household income, household's average monthly income, controller of the household spending decisions, children should contribute financially to the household income, amount children contribute towards family expenses, purpose of child income generation in the family, would stop children from working when financial support is readily made available, and family experience changes in the pattern of resource flow over generations) studied under wealth flows in families with varied degrees of freedom (2, 3, 3, 1, 2, 3, 2, & 1) respectively postulate a strong relationship which suggests that wealth flows in families strongly predict parents' engagement of children in labor. This outcome confirmed previous studies, which found that child labor is higher in families that have

access to land and livestock in rural areas and small business [68–70].

The study found that parents who believe that children should contribute financially to the household income had higher likelihood of engaging children in labor. The plausible explanation for this finding could be that these parents are unemployed, have a debt, and yet, want to ensure their children receive financial support from noncustodial parents to cover all their basic needs. This finding corroborated with a previous study which found that parents engage their children in their own occupations so as to benefit from their economic value [62].

Surprisingly, parents who endorsed that they would stop a child from working when financial support is readily available had lower odds of engaging children in labor. The plausible explanation for this finding could be that these participants believe that if financial support is readily made available, it could provide them with financial flexibility to cover the high costs of raising children, allowing them to prioritize essential needs like food, housing, and childcare. This outcome corroborated with a previous study which found that families with access to credit are considerably less likely to put children to work during a period of economic volatility [71].

Besides, parents who do not know whether they would stop a child from working when financial support is readily available had decreased odds of engaging children in labor. The plausible explanation to this finding could be that these parents do not have financial challenge which could warrant them engage their children in labor. Also, it could be that the primary wage earner of the household is gainfully employed and his or her income is able to cater for all expenses of the household, and that do not require financial support from their children for household expenses. This outcome is in line with previous studies which found that increases in income available to the household will tend to lower child participation in work and this reduction in work activities will tend to be stronger. Further, the authors postulated that rising incomes are associated with improvements in the family's ability to triage economic shocks without child labor, shifting production outside of the home, and a greater demand for education and leisure [72,73].

The study found that parents had varied average number of children with varied number of children desire. This finding suggests that fertility is predicted by countless factors which include desire for large families, prevalent of child mortality, knowledge on the reasons to use family planning, and access to quality family planning services. This finding agrees with a previous study which found that 22.3% of women stated that they want to have 1 child and equally 52.7% of men and 52.7% of women wanted to have 2 children [74].

It emerged that having many children does not increase the likelihood of child labor. The reason for this finding could be that these participants are capable of catering for their children, and that do not need them supporting with finances in the family. Further, it could be that these parents are aware that if children are engaged in labor, they are not paid, even if they are, they receive very low wages, and at times too, they are not protected. However, those parents who said having many children increases the likelihood of child labor reason could be that they do not have sustainable financial source. This outcome refuted a previous study which found that an increase in child survival probability induces unskilled workers to have more children, thus increasing the child labor supply [75].

Relationship was identified between fertility and parents' engagement of children in labor. Due to this, the null hypothesis was not confirmed. A *p*-value of <0.001 found in the variables (number of children, number of children desire, and having many children increases the likelihood of child labor) studied under fertility with varied degrees of freedom (3, 2, & 2) respectively indicate that fertility has a strong influence on parents' engagement of children in labor. This outcome was consistent with a previous study which found that the total fertility rate of mother had a positive relationship with child labor. The authors further posited that for more than two children, the relationship was positive and significant [76].

It was brought to the fore that parents who had just a child (one) had lower odds of engaging children in labor. The plausible explanation for this finding could be that these parents are aware that most children laborers are doubly disadvantaged when they reach working age. As most are denied a chance of going to school, their prospects for decent work in youth and adulthood are severely constrained. This finding suggests that parents with one child do not engage the child in labor. Hence, they see themselves as capable of taken care of the child.

Besides, parents who were not sure whether having many children increases the likelihood of child labor had a lower likelihood of engaging children in labor. The plausible explanation for this finding could be that these parents are not aware about the link between fertility and child labor. With this, parents might not see the need to engage children in labor. Further, since these parents lack understanding about the relationship between fertility and child labor, it might lead them to be more cautious and less willing to rely on child's financial contributions in the family as a means of survival or economic gains.

The study found that three-quarters of the participants do engage their children in child labor. This outcome is almost in line with a previous study conducted in Ethiopia (Amhara region), which found that 51% of children in Ethiopia were working of which the proportion reaches 64% in the Amhara region [77]. The authors further stressed that about 30% of those children were in hazardous labor. Furthermore, this outcome is almost the same as a previous study conducted in Ghana and Côte d'Ivoire which also found that 67.1% of children had worked in agriculture in the past 12 months [78]. This finding suggests that majority of parents in the Ashanti Region of Ghana engage children in labor. This underscores a targeted educational intervention to help educate parents across Ghana especially, those in the Ashanti Region in order to enlighten them of the long-term health consequences including cancer, infertility, and chronic backpain these children are likely to experience later in life coupled with poverty and lack of efficient health and social security schemes. It could be possible, for one to say that these parents are illiterate, and that are not aware of the consequences of child labor. It could also be that they are not gainfully employed, and that what they earn from the menial work they do cannot sustain the household.

However, a quarter reported that they do not engage children in child labor. This outcome refuted a previous study conducted in 221 Districts of 18 Developing Countries, which found that children whose parents are gainfully employed are significantly more likely to engage in labor, even when controlling for household wealth [79]. Further, the finding also disagrees with another study conducted in Ghana, which found that when caregivers lack time, its leads to increased child work and

reduced school attendance [80]. Furthermore, the current study's findings refuted the findings of another cross-sectional study conducted among 473 parents in Nigeria which found that 39% believed their school-aged children should work, 61% do not support child labor [81]. The implication of this finding is that a significant proportion of parents in the Ashanti Region of Ghana value education and child development, and that do allow their children to go to school in order to brighter their chances of getting better employment. So that in the future, they can enjoy better life. It is possible for one to say that these parents are rich, and that they do not lack in terms of money to warrant them to rely on child's contribution to family's income for survive.

5. Conclusion

This study found that a substantial proportion of parents in the Ashanti Region of Ghana engage their children in labor. Whether undertaken knowingly or unknowingly, child labor exposes children to a range of adverse health outcomes that may manifest later in life. Engagement in hazardous work can lead to long-term physical and psychosocial consequences, including chronic musculoskeletal disorders, infertility, and increased cancer risk, many of which may only become apparent in adulthood and are therefore difficult to detect or attribute directly. These risks are further exacerbated by persistent poverty and the limited availability of effective health and social protection systems.

The findings underscore the need for a multifaceted response to child labor that goes beyond legal prohibition alone. Strengthening and enforcing existing legal frameworks, raising public awareness of the long-term consequences of child labor, and expanding social protection mechanisms to support vulnerable households are essential. In particular, national labor laws should be reviewed to ensure that the minimum legal age for work is clearly defined and effectively enforced, in line with international standards. Addressing both the economic drivers and the normative beliefs that sustain child labor is critical to achieving meaningful and sustainable reductions in child labor in Ghana.

6. Limitations of the study

Despite efforts to ensure methodological rigor, this study has several limitations. First, the exclusive use of a quantitative cross-sectional design constrained the ability to capture the contextual depth and lived experiences underlying parental decisions regarding child labor. Complex social norms, household dynamics, and motivations may have been oversimplified through numerical indicators.

Second, the cross-sectional nature of the data limits causal inference, as observed associations cannot establish temporal or causal relationships between wealth flows, fertility, and child labor engagement. Third, reliance on self-reported data may have introduced reporting bias, particularly given the social sensitivity and legal implications surrounding child labor.

Future research would benefit from mixed-methods or longitudinal approaches to better capture the nuanced pathways through which economic conditions, fertility dynamics, and cultural norms interact to shape child labor practices over time.

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Abbreviations

DV	Dependent variable
IV	Independent variable
SDGs	Sustainable Development Goals
SNA	United Nations System of National Accounts
SPSS	Statistical Package for the Social Sciences

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Review

Review of Body Shape and Size Index and obesity insights from recent studies in Pakistan

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Abstract: Obesity has emerged as a significant public health crisis globally, with its prevalence rising at an alarming rate across various demographics. Characterized by excessive fat accumulation, obesity is associated with numerous health complications, including cardiovascular diseases, type 2 diabetes, and certain cancers, along with mental health issues such as anxiety and depression. In Pakistan, the situation is particularly critical; studies indicate that adult obesity rates have increased from 21% in 2016 to 29% in 2024, while childhood obesity has surged from 9% to 19% over the same period. These trends highlight the pressing need for effective obesity assessment strategies and targeted public health interventions to mitigate the impact of obesity on health outcomes in the country. The traditional measure of obesity, the Body Mass Index (BMI), has been widely used due to its simplicity in calculating weight relative to height. While BMI provides a quick classification of individuals as underweight, normal weight, overweight, or obese, it has inherent limitations. BMI fails to consider variations in body composition, fat distribution, and demographic factors such as age, gender, and ethnicity. Reliance solely on BMI may lead to misclassification of individuals' health risks, undermining the effectiveness of obesity management strategies. There is a growing recognition for alternative measures, including the Body Shape and Size Index (BSSI), which accounts for multiple anthropometric variables to provide a more comprehensive assessment of obesity and its associated health risks. This review focuses on methodological advancements in the field of obesity assessment, specifically the evolution of BSSI, and synthesizes findings from recent studies conducted in Pakistan. Drawing on data from diverse populations, these studies highlight the potential of BSSI to improve obesity risk stratification by integrating measurements such as body surface area (BSA), weight, and height. The use of quantile regression (QR) techniques to create growth charts for BSSI enhances understanding of body composition across different age groups and genders, offering valuable insights for public health policy formulation. The implications of these findings underscore the importance of integrating BSSI into national health monitoring systems and public health initiatives, which could lead to more effective obesity prevention and management strategies tailored to the unique characteristics of Pakistani populations. Implementing innovative assessment tools like BSSI is crucial for addressing the pressing public health crisis of obesity and improving health outcomes in diverse communities.

Keywords: obesity; Body Shape and Size Index (BSSI); body mass index (BMI); public health; anthropometric measurements; quantile regression (QR); health outcomes; obesity assessment tools

1. Introduction

1.1. Definition of obesity and its health implications

Obesity is a complex and multi-factorial chronic disease characterized by excessive fat accumulation that poses health risks [1]. Based on body mass index (BMI), a popular index, it is normally defined by special criteria of weight, namely normal weight, overweight, and obesity [2]. Obesity can lead to many associated ailments such as type 2 diabetes mellitus cardiovascular diseases, specific types of cancer, and musculoskeletal diseases [3,4]. Besides, being overweight is another cause of worsening mental health, leading to depression and even anxiety [5–7]. These health implications stress a need for efficient evaluation and intervention approaches as more people develop obesity in recent years [8] (**Figure 1**).

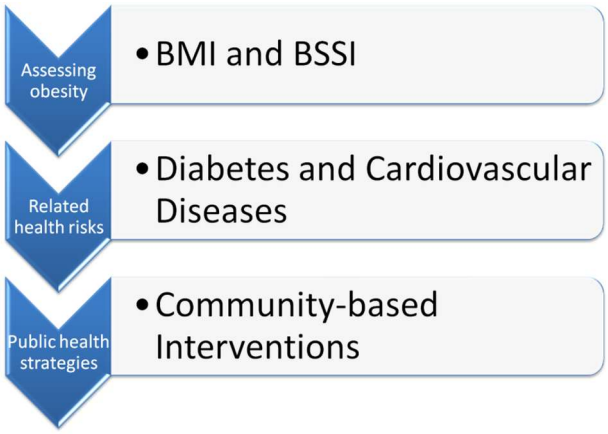

Figure 1. Framework for analyzing obesity.

1.2. Current prevalence of obesity in Pakistan

Pakistan faces a growing public health crisis related to obesity. Based on recent approximations, it became known that the proportion of obesity in the adult population in Pakistan has also increased significantly, from 21% in 2016 and 26% in 2021 to 29% in 2024 [9–13]. The adults are not left out on this upward prevalence trend; childhood obesity stands at 9%, 15% in the past five years, and 19% in 2024 for both the urban and rural dwellers [14–16]. It becomes essential to come up with prevention measures for obesity, especially for those groups that have very little access to health care and nutritional information. The disease of obesity is a global phenomenon that is driven by changes in lifestyles, urbanization, and the availability of processed and energy-dense food [17,18] (**Table 1**).

Table 1. Prevalence of obesity in Pakistan (2016, 2021, 2024).

Year	Adult obesity rate (%)	Childhood obesity rate (%)
2016	21%	9%
2021	26%	15%
2024	29%	19%

1.3. Overview of traditional methods to assess obesity: BMI

BMI is the most widely used tool for assessing obesity in clinical settings and epidemiological studies. It is calculated using an individual's weight in kilograms divided by the square of their height in meters (kg/m^2) [6,19]. BMI offers a simple and quick method for categorization, allowing healthcare professionals to classify patients into different weight categories (normal weight, overweight, and various degrees of obesity) without requiring sophisticated equipment or extensive training. According to the WHO classifications, a BMI of 18.5–24.9 kg/m^2 is considered normal, while a BMI of 25.0–29.9 kg/m^2 indicates overweight, and a BMI of 30.0 kg/m^2 and above is classified as obese [20,21].

There are problems with measurements such as BMI; they cannot very accurately characterize some degree of body fatness and may misrepresent certain health risks of obesity in various populations [22,23]. BMI does not reflect differences in fat topography, body build, age, sex, or ethnic background [24,25]. Neighbors might have completely different body make-up even if their BMI is the same, and, therefore, BMI is not the optimal tool that might help understand the risks associated with obesity [26–28]. This has led to a replacement for an increasing concern that reliance on the BMI measurement can cause misinterpretation of people as either healthy or at risk for obesity-related complications [29].

Limitations of BMI as an accurate measure of body fat

The problem with BMI is the fact that it has several drawbacks that defeat the purpose of using it as a good measure of body fat. One of the biggest issues is that BMI does not differentiate between lean body mass (muscle) and fat mass [30,31]. Sportspeople or individuals with large muscles will have bigger BMIs thanks to mass from muscles, yet they have low body fat [32,33]. People with normal weight may possess a high amount of VF, which is determined by health risk levels for metabolic diseases; thus, a normal-weight person is at a higher risk of disease than what the scale depicts [29,34,35].

BMI is known to be sensitive to the differences in population and demographics in that constant fluctuation renders it a poor barometer of obesity-related health risks [35,36]. Some ethnic group individuals have different body fat topographical distributions that are not captured by BMI. People from Asian countries develop metabolic disorders at significantly lower BMIs compared to people of European descent [37]. The employment of one approach to categorize obesity may adversely affect the outcomes of the obesity intervention process.

1.4. Introduction and rationale for the development of Body Shape and Size Index (BSSI)

In response to the limitations of BMI, researchers have sought alternative measures for assessing obesity that more accurately reflect body fat distribution and body composition. One such innovation is the BSSI, which incorporates multiple anthropometric measurements to provide a more holistic assessment of an individual's health status [38]. The BSSI is designed to quantify body shape and size using components such as body surface area (BSA), weight, and height, thereby offering a more comprehensive perspective on an individual's risk of obesity-related

health complications. The development of the BSSI aims to address the shortcomings of traditional methods by offering a more accurate representation of body composition and fat distribution. It considers factors such as age, gender, and population differences that influence body shape and size [39]. By utilizing quantile regression techniques, researchers can create growth charts that provide valuable insights into BSSI at different age groups, thereby identifying trends related to obesity risk [31].

The introduction of the BSSI is particularly relevant in the context of populations like Pakistan, where the prevalence of obesity is rising, yet traditional metrics may not adequately capture the true burden of obesity [31]. By developing and validating the BSSI, researchers aim to create a tool that public health officials and practitioners can use to assess obesity risk more accurately and devise effective intervention strategies tailored to the unique characteristics of the population. Through the BSSI, public health programs can focus on addressing the specific factors contributing to obesity while considering the demographic diversity of individuals. The BSSI has the potential to enhance the understanding of body shape and size variations in different populations, ultimately leading to improved health outcomes and the reduction of obesity-related health disparities (**Table 2**).

Table 2. Differences between BMI and BSSI.

Metric	BMI	BSSI
Definition	Weight (kg)/height (m^2)	Combines weight, height, and BSA
Considerations	No consideration for fat distribution	Considers fat distribution, body composition
Population variability	Lacks precision across demographics	More accurately reflects ethnic differences
Health risk assessment	May misclassify health risks	Provides a nuanced assessment of health risks

1.5. Objectives

The objective of this review article is to address the pressing public health crisis of obesity, particularly in the context of Pakistan, by critically assessing traditional obesity assessment methods like BMI and proposing BSSI as a more comprehensive alternative. The review aims to explore recent advancements in the application of BSSI, including the use of quantile regression techniques for developing growth charts, to enhance the accuracy of obesity risk assessments. It strives to inform public health policies and intervention strategies that consider the socio-economic and demographic factors influencing obesity, ultimately advocating for a multidimensional approach to obesity prevention that integrates innovative measures alongside traditional metrics.

2. Literature review

2.1. The concept of BSSI

The BSSI is an innovative metric designed to assess obesity by taking into account multiple anthropometric measurements, aiming to provide a comprehensive understanding of body composition and fat distribution. Traditional methods of measuring obesity, primarily BMI, rely solely on weight-for-height calculations,

often leading to incomplete assessments of an individual's health status [40]. In contrast, the BSSI synthesizes several components: weight, height, and BSA, which collectively facilitate a more holistic evaluation of body shape and size.

The BSSI is particularly valuable because it considers not only absolute weight but also the surface area in conjunction with height, promoting a better understanding of how body fat is distributed across various populations [40]. This multidimensional approach allows practitioners to evaluate obesity risk more accurately by considering ethnic differences, variations in body composition related to lifestyle factors, and the physiological implications of specific body shapes [41–44]. Given the increasing prevalence of obesity, particularly in countries like Pakistan, the BSSI could serve as a significant tool for public health professionals when implementing targeted health interventions that consider demographic variability.

Research indicates that the BSSI can highlight individuals at risk for obesity-related health complications, as it provides a finer resolution of assessment compared to BMI [30]. For instance, individuals might present with similar BMIs but possess varying levels of fat mass and distribution. BSSI has thus emerged as a more nuanced indicator in recognizing health risks, especially among diverse populations where body composition patterns differ [12,45].

2.2. Methodological approaches

2.2.1. Quantile regression (QR) as a statistical tool

QR is a statistical technique that extends traditional linear regression methods by estimating the conditional quantiles of the response variable [40]. Unlike ordinary least squares regression, which focuses on the mean of the dependent variable, QR provides insights into the distributional impact of independent variables across various quantiles. This approach is particularly beneficial in health studies that investigate the relationships between body shape indices and health outcomes, as it allows for a more comprehensive understanding of how body composition impacts health at different levels of obesity.

Within the context of BSSI, QR has been utilized to construct growth charts that reflect the distribution of BSSI across different age groups and genders [28]. By employing quantile regression, researchers can portray how changes in body shape and size are associated with varying obesity levels, thus offering valuable insights into health trends across diverse demographic segments [29,30]. This methodology is poised to yield tailored health recommendations by indicating not only whether an individual falls below, at, or above recommended thresholds but also how their body shape and size should influence clinical assessments and health interventions.

In comparative studies, QR has been shown to outperform traditional statistical methods, particularly in scenarios where the relationship between variables is non-linear or affected by outliers [28]. Given that obesity manifests distinctly across various population segments, the applicability of QR in analyzing BSSI metrics enhances the precision of obesity assessments, thereby supporting academic discourse on health equity and targeted interventions.

2.2.2. Comparative studies

Recent research has focused on comparing QR with more traditional metrics like Gaussian percentiles and raw percentiles when analyzing BSSI. This comparative examination has significant implications for the understanding and interpretation of growth patterns among various populations. Hussain et al. [31] conducted a comparative evaluation that illustrated QR's superiority in capturing more nuanced variations in body shape and size across the obesity spectrum.

In these studies, methodologies typically employ a combination of statistical techniques to assess how different percentile methods correlate with health outcomes associated with obesity. For example, Gaussian percentiles assume a normal distribution of the data, which can mask variations present in skewed distributions typically observed in anthropometric data [23]. Raw percentiles merely rank the data without context, potentially leading to misinterpretations in understanding growth trends related to obesity.

QR allows for the examination of not only central tendencies but also variations across the entire distribution. It has been particularly useful in uncovering how socioeconomic factors and gender disparities impact obesity prevalence and health outcomes [20,34]. Moreover, studies have illustrated that QR can provide insights into the influence of income on BSSI, helping public health officials tailor interventions based on socioeconomic contexts.

The comparative studies have shown that while both Gaussian and raw percentiles provide essential data about population growth, QR yields deeper insights concerning subgroup variations. This is particularly relevant in the Pakistani context, where socio-economic status and cultural factors play a critical role in shaping health behaviors and outcomes [17,28–30]. By acknowledging these factors, QR-based analyses can facilitate the design of targeted public health programs that consider local contexts and conditions.

The use of BSSI as an alternative assessment tool, combined with the advantages of quantile regression, represents a crucial advancement in obesity research. Continued comparative studies are necessary to further validate BSSI through diverse methodologies, laying the groundwork for more effective public health strategies to combat the rising tide of obesity-related health issues, particularly in developing countries such as Pakistan.

3. Summary of findings from recent studies

3.1. Inclusion criteria for reviewed studies

To ensure the relevance and reliability of the findings discussed, the reviewed studies adhered to the following inclusion criteria.

3.1.1. Population characteristics

- Participants included children, adolescents, and adults from diverse age groups.
- Studies encompassed both genders and various ethnic and regional groups within Pakistan.
- Socioeconomic diversity was considered, including participants from different income levels and urban/rural settings.

3.1.2. Sample size

- Studies employed sufficiently large sample sizes (generally over 700 participants) to ensure statistical validity and representativeness.

3.1.3. Anthropometric measures

- Included studies utilized measurements such as weight, height, BSA, and other relevant anthropometric parameters necessary for calculating BSSI.
- Studies employed standardized measurement techniques to ensure data comparability.

3.1.4. Study design

- Cross-sectional studies for establishing growth charts and assessing prevalence.
- Longitudinal studies for examining changes over time and assessing health outcomes.
- Comparative studies evaluating different statistical methods (e.g., quantile regression vs. traditional percentiles).

3.1.5. Data quality and representativeness

- Participants were selected based on clear inclusion/exclusion criteria, ensuring data quality.
- Studies aimed for representative samples reflective of the general Pakistani population or specific subgroups (e.g., low-income, urban/rural).

3.1.6. Analytical methods

- Use of validated statistical techniques such as quantile regression, Gaussian percentiles, or *Z*-scores.
- Clear documentation of methods used for data analysis and interpretation.

3.2. Establishing growth charts for BSSI

In recent efforts to establish growth charts for the BSSI, Hussain et al. [31] utilized a comprehensive methodology that involved extensive data collection from diverse demographic groups across Pakistan. The study comprised a sizable sample of over 7224 participants, which included children, adolescents, and adults, thus providing a robust dataset that reflects various ages, genders, and socioeconomic backgrounds. The participants were meticulously selected to ensure representative demographics, paying particular attention to variations in ethnic backgrounds, urban versus rural residency, and gender distribution [31].

The main findings of this study revealed a significant positive correlation between BSSI and traditional obesity indicators, such as BMI. The research demonstrated that higher BSSI values were associated with increased obesity levels and a higher prevalence of obesity-related co-morbidities, including hypertension and diabetes. The study highlighted critical thresholds for BSSI that could effectively stratify risk levels among Pakistani populations, paving the way for tailored obesity prevention campaigns [31].

The implications of these findings for public health policies in Pakistan are profound. The establishment of BSSI growth charts provides healthcare professionals and policymakers with a valuable tool to identify at-risk individuals more accurately. It supports the development of targeted intervention strategies

aimed at addressing the growing obesity epidemic in the country. As obesity rates continue to rise, public health campaigns can leverage this information to promote healthier lifestyle choices, preventive measures, and community-based health initiatives that emphasize the importance of monitoring body composition along with traditional metrics like BMI [44].

3.3. Examining the relationship between obesity and income distribution

Another significant exploration into the determinants of obesity was conducted by Hussain et al. [31], focusing on the relationship between obesity and income distribution in Pakistan. This study utilized a statistical framework that considered various socioeconomic factors, analyzing data from approximately 2223 participants stratified by income levels. The study incorporated detailed demographic data, including age, gender, and regional characteristics, to provide a nuanced understanding of how income influences body composition metrics like BMI and BSSI.

The findings revealed that individuals from lower-income brackets exhibited higher prevalence rates of obesity compared to their higher-income counterparts. Furthermore, the study uncovered notable gender disparities; women, particularly from lower socioeconomic backgrounds, showed significantly higher obesity rates than men. This trend was attributed to various factors, including limited access to nutritious foods, lack of awareness regarding healthy lifestyle choices, and cultural factors that influence food consumption patterns [30,42].

This research highlights the critical need for public health interventions that address socioeconomic inequalities in the context of obesity. Policymakers are encouraged to consider targeted outreach programs that provide education on nutrition and physical activity, especially in low-income communities. By addressing the unique challenges faced by different income groups, public health strategies can be designed to effectively combat obesity while also promoting health equity [30,43].

3.4. Comparative evaluation of percentile methods for BSSI

The comparative analysis of percentile methods for BSSI was conducted by Shehzad et al. [43], which investigated the efficacy of various statistical approaches for establishing growth charts. This study explored three distinct percentile methodologies: quantile regression, Gaussian percentiles, and raw percentiles, analyzing data from a diverse cohort of 9906 individuals from both urban and rural settings in Pakistan. The comparative nature of this research aimed to discern the impact of different methodologies on the interpretation of obesity and growth trends within the population.

Findings from the study indicated that quantile regression provided a more accurate portrayal of the distribution of BSSI within the cohort, particularly revealing skewness and variations that traditional methods failed to capture. While Gaussian percentiles offered a standard normalization, their underlying assumptions regarding data distribution often led to misclassification of obesity risk among specific subgroups particularly in populations with higher variability in body

composition. Raw percentiles, although simpler, did not offer insights into the underlying distribution characteristics, which are crucial for understanding growth trends [1].

The implications of method choice on understanding growth trends in the population are substantial. By adopting quantile regression for establishing BSSI growth charts, researchers and public health officials can acquire a more nuanced understanding of obesity within different demographic segments, allowing for the development of tailored interventions that address specific population needs. This study reinforces the importance of methodological rigor in obesity research and suggests that adopting advanced statistical techniques can significantly enhance the quality of insights derived from anthropometric data [30].

3.5. Comparison of quantile regression and Gaussian *Z*-scores to BSA

A pivotal study by Hussain et al. [40] focused on comparing quantile regression with Gaussian *Z*-scores in assessing BSA as an integral component of BSSI measurement. The methodology encompassed a longitudinal framework involving a sample of 3473 participants, with detailed anthropometric measurements taken to accurately calculate both BSA and BSSI values over time. By employing a robust statistical design that included repeated measures, the study aimed to elucidate the significance of BSA as a public health measure in conjunction with BSSI [28–30].

The results indicated that while Gaussian *Z*-scores offered a standardized measure, quantile regression provided deeper insights into the variability of BSA among different demographic segments. The study concluded that using quantile regression allowed for a more flexible interpretation of the relationships between BSA, body composition, and health outcomes across varied percentiles, thereby enhancing the understanding of obesity and its associated risks [29].

This study's contributions extend beyond methodological advancements, as they emphasize the need for integrated approaches that combine various anthropometric measures when assessing health outcomes. By linking BSA closely with BSSI evaluations, public health officials can better understand the multifaceted nature of obesity and its implications. This could potentially lead to enhanced health monitoring systems that account for various risk factors associated with body composition, thereby fostering a more comprehensive public health strategy to combat obesity-related health issues effectively [28,29] (**Table 3**).

Table 3. Comparative summary of key studies on BSSI.

Study	Sample Size	Methodology	Key Findings	Implications
Hussain et al. [40]	7224	Quantile regression for growth charts	Established correlation between BSSI and obesity-related co-morbidities.	Provides a tool for targeted public health interventions and risk assessment tailored to Pakistani populations.
Hussain et al. [42]	2223	Statistical analysis of income	Found that lower income correlates with higher obesity rates, particularly among women.	Underlines the need for socioeconomic-targeted health programs and policies addressing inequalities.
Shehzad et al. [43]	9906	Comparative analysis of percentiles	Illustrated the efficacy of quantile regression over traditional methods.	Supports adopting QR for more accurate growth charts and risk assessment in diverse populations.
Hussain et al. [31]	3473	Longitudinal study of BSA	Highlighted the variability of BSA and its implications for health outcomes.	Promotes integrated anthropometric assessments for better health monitoring and intervention planning.

4. Implications of BSSI for public health

4.1. Relevance of BSSI as a potential tool for obesity assessment

The BSSI has gained relevance as a vital tool for assessing obesity, particularly as concerns mount over the limitations of the conventional BMI. While BMI remains a widely employed metric for categorizing individuals into weight classifications, it does not account for critical factors such as body fat distribution and muscle mass, which significantly influence health outcomes [28]. By integrating multiple anthropometric measurements, the BSSI offers a more nuanced perspective on body composition, thereby enhancing its utility in clinical settings and public health initiatives.

Research has demonstrated that the BSSI provides a more accurate reflection of obesity-related health risks compared to BMI. Studies indicate a strong correlation between elevated BSSI values and the prevalence of obesity-related co-morbidities, such as hypertension, type 2 diabetes, and cardiovascular diseases, particularly within diverse populations [27,30,44]. This ability to identify individuals at higher risk of developing these conditions underscores the significance of adopting BSSI as a standard assessment tool.

The BSSI has the potential to enhance early detection and intervention strategies for obesity management. As obesity rates climb globally, the ability to detect variations in body shape and size can inform more effective public health campaigns aimed at obesity prevention. The BSSI not only identifies individuals at risk but also aids clinicians in personalizing treatment approaches based on an individual's unique body composition profile [26,30]. This capability is particularly crucial in areas like Pakistan, where diverse body shapes and cultural practices significantly influence obesity trends and health outcomes.

4.2. Recommendations for integrating BSSI in public health strategies

For the effective integration of BSSI into public health strategies, several actionable recommendations can be proposed. Firstly, extensive training programs for healthcare professionals must be implemented to ensure that they understand the methodology and advantages of BSSI over traditional measures like BMI. Such education will help clinicians better assess and interpret BSSI data while using it to inform treatment decisions and community health initiatives [14,30]. These training programs should be embedded into existing healthcare education frameworks and continuing education opportunities to promote widespread understanding of BSSI.

Secondly, public health campaigns should raise awareness about BSSI among the general population. These campaigns must emphasize the shortcomings of BMI as a singular measure of obesity and promote the understanding that the BSSI offers a more comprehensive evaluation of health risks associated with body shape and size. By focusing on awareness of body composition rather than weight alone, public health messaging can encourage healthy lifestyle choices that prioritize overall health rather than conforming to arbitrary weight benchmarks [21,23,45,46].

Integrating BSSI into national health monitoring systems is crucial. Policymakers should consider the utility of BSSI in vital health surveys that collect

demographic data on body shape and size across various population segments. This type of data can illuminate patterns of obesity and inform targeted public health interventions tailored to specific demographic characteristics [30,31,47]. By aligning public health surveillance with BSSI measures, authorities can establish benchmarks for successful interventions and allocate resources more effectively to combat obesity.

A commitment to ongoing research is essential for the continuous refinement of BSSI applications in diverse populations. Public health entities should fund research initiatives aimed at validating BSSI across various demographic contexts and exploring its correlation with other health outcomes. Research efforts should also investigate how BSSI can be effectively employed in combination with existing obesity assessment tools. This multidimensional approach can lead to a more holistic understanding of obesity management and inform the adaptation of public health strategies to local needs and trends.

4.3. Potential future research areas focusing on BSSI and its applications in different demographics

The development of BSSI opens several avenues for future research, particularly in its application across different demographics. One of the key areas for exploration is the validation of BSSI in diverse ethnic populations within Pakistan and globally. Future studies should focus on assessing how variations in body composition across ethnic groups may influence the relationship between BSSI, health risks, and obesity-related diseases. Understanding these dynamics will not only enhance the applicability of BSSI but also contribute to personalized clinical practices that consider ethnic variations in body shape and composition [30,36,48–52].

Another promising area of research involves longitudinal studies that track how changes in BSSI correlate with health outcomes over time. By examining large populations across various demographics, researchers can gather insights into how shifts in body shape and size impact metabolic health, psychological well-being, and overall quality of life. Such studies are essential for establishing a stronger causal framework linking BSSI with health outcomes, thereby solidifying its role as a critical measure in obesity assessment [28].

Exploring the integration of BSSI with behavioral and environmental factors may shed light on effective intervention strategies. Future research can focus on how socioeconomic, cultural, and environmental contexts influence body shape and size, shaping obesity risk. This exploration can facilitate the design of community-specific interventions that target factors known to be associated with higher BSSI measurements, leading to tailored public health programming [7,28,53].

The advancement of digital health technologies presents an opportunity for innovative research into the application of BSSI. Researchers might explore how smart phones and wearable devices can be utilized for real-time tracking of body measurements linked to BSSI, fostering more dynamic health assessments. Such technology-driven approaches could enable preventive health strategies tailored to individual needs, promoting proactive rather than reactive health management

[15,28,54].

The emerging relevance of BSSI as a tool for obesity assessment underscores the necessity for its integration into public health strategies aimed at addressing the growing obesity crisis. By adopting the BSSI alongside traditional metrics, healthcare professionals can more accurately identify and treat individuals at risk, facilitating targeted interventions that respond to the unique needs of diverse populations. In light of the dynamic nature of obesity as a public health issue, continued research focusing on refining BSSI, understanding its implications across different demographics, and fostering awareness will provide valuable insights that support effective combating of obesity and its associated health risks. A multi-faceted approach to obesity assessment not only enhances health equity but ultimately leads to improved health outcomes and reduced health disparities across populations. The integration of BSSI within public health infrastructures positions it as an essential instrument in contemporary obesity research and strategy formulation. As the landscape of public health evolves, embracing innovative metrics like BSSI will be crucial in addressing the complexities of obesity in a holistic, informed manner.

4.4. Validation of BSSI beyond the Pakistani context

The current body of research on BSSI predominantly pertains to its development and validation within the Pakistani population. The extensive studies conducted by Hussain et al. [31,40,42] involve large, diverse cohorts from across Pakistan, encompassing various age groups, genders, and socio-economic backgrounds. These investigations have demonstrated significant correlations between BSSI and traditional obesity indicators, as well as its potential utility in risk stratification and growth chart development tailored to the Pakistani demographic. However, there is a conspicuous absence of evidence indicating that BSSI has been validated in populations outside Pakistan or in broader international contexts. While the conceptual framework of BSSI considers ethnic differences and demographic variability, empirical validation studies in other ethnicities or geographic regions are lacking. Although promising within the Pakistani setting, the generalizability and applicability of BSSI beyond this context remain to be established through further cross-cultural and multi-ethnic validation studies. Such research is essential to determine whether BSSI can serve as a reliable and universal tool for obesity assessment across diverse populations globally [55–65].

4.5. Challenges in practical implementation of BSSI

Implementing BSSI as a standard tool for obesity assessment in Pakistan faces numerous practical challenges. One of the primary obstacles is the resource and infrastructure limitation, particularly in rural and underserved areas. Accurate measurement of components such as BSA, height, and weight requires calibrated equipment and standardized protocols, which may be lacking in many healthcare settings. Without proper infrastructure, consistent and reliable data collection becomes difficult, hindering the widespread adoption of BSSI. Another significant challenge pertains to training and capacity building among healthcare professionals.

Transitioning from traditional BMI assessments to BSSI demands comprehensive training programs to ensure accurate measurement, calculation, and interpretation of results. Many healthcare workers, especially those in resource-constrained environments, may have limited access to ongoing educational opportunities, which could compromise the effectiveness of implementation. Ensuring that personnel are adequately skilled and confident in using BSSI is crucial for its successful integration.

Standardization and validation across diverse populations pose additional hurdles. Pakistan is a multicultural society with varied ethnicities, ages, and socio-economic backgrounds, all of which influence body composition. For BSSI to be effective as a universal tool, it must be validated across these different demographic groups, requiring large-scale, longitudinal studies. Developing region-specific thresholds and cutoffs that accurately reflect local population characteristics is resource-intensive and time-consuming, delaying its routine use. Cultural and societal acceptance also influence the feasibility of adopting BSSI. Public perceptions about body measurements and health assessments can vary widely, and there may be resistance or misconceptions about new indices. Cultural sensitivities related to body image and health-related privacy issues can further impede community engagement and compliance. Overcoming these societal barriers necessitates targeted awareness campaigns and community education to foster acceptance and understanding.

Integration into existing public health systems presents administrative and policy-related challenges. Updating national health monitoring protocols and surveillance systems to incorporate BSSI requires policy revisions, resource allocation, and coordination among multiple stakeholders. These bureaucratic processes can be slow and may face resistance from institutions accustomed to traditional metrics like BMI. Additionally, the initial costs associated with acquiring measurement tools, training personnel, and updating data systems could be substantial, raising concerns about sustainability and cost-effectiveness. Data management and privacy considerations add another layer of complexity. Collecting detailed anthropometric data linked with health records demands robust data security measures to protect individual privacy. Ensuring ethical handling of sensitive information becomes more challenging when scaling up to national levels, especially in the absence of clear data governance frameworks.

Public awareness and education about the benefits of BSSI are essential but challenging to achieve. Many individuals and communities may lack understanding of the limitations of BMI and the advantages of a more comprehensive assessment tool. Overcoming misinformation, cultural barriers, and low health literacy requires well-planned and culturally sensitive communication strategies. Technological barriers must be addressed. The potential of digital health tools and real-time monitoring of BSSI is promising but depends on reliable internet connectivity, digital literacy, and access to smartphones or wearable devices. In many parts of Pakistan, such technological infrastructure remains limited, restricting the feasibility of deploying high-tech solutions for large-scale BSSI assessment and monitoring.

While BSSI offers significant potential for improving obesity assessment and management, its practical implementation is challenged by infrastructural,

educational, cultural, policy, and technological barriers. Overcoming these obstacles requires coordinated efforts among policymakers, healthcare providers, researchers, and communities. Only through comprehensive planning and resource allocation can BSSI be effectively integrated into Pakistan's public health framework, ultimately contributing to more accurate and equitable obesity management strategies.

5. Conclusion

The BSSI represents a significant advancement in the field of obesity assessment and present a viable alternative to the traditional BMI. This comprehensive review highlights the growing concern of obesity as a multifaceted public health crisis, particularly within the context of Pakistan, where prevalence rates have escalated alarmingly in recent years. The limitations of BMI, which primarily relies on height and weight to classify individuals, have been well-documented and underscore the urgent need for a more nuanced approach to understanding body composition and its associated health risks. As demonstrated in various studies, the BSSI's integration of multiple anthropometric measurements allows for a more accurate reflection of body fat distribution, ultimately leading to improved identification of individuals at higher risk for obesity-related diseases. The evidence presented through recent research indicates that the BSSI serves as a valuable tool for not only diagnosing obesity but also for informing targeted intervention strategies. Researchers have established correlations between BSSI values and the prevalence of obesity-related co-morbidities, such as hypertension and diabetes, which are critical in shaping obesity management policies. The establishment of growth charts for BSSI, supported by quantile regression techniques, offers healthcare professionals a robust framework for assessing obesity risk across diverse population segments, considering factors such as age, gender, and ethnicity. This multidimensional approach is particularly pertinent in multicultural societies like Pakistan, where variances in body composition could have far-reaching implications for health outcomes.

For public health policymakers, the findings of this review emphasize the necessity of integrating BSSI into national health monitoring systems and intervention programs. By shifting the focus from BMI to a more multifaceted measure like BSSI, public health initiatives can be adapted to reflect the unique demographic and socio-economic circumstances confronting different populations. The evidence suggests that tailored educational campaigns and community-based health interventions, rooted in the insights gleaned from BSSI assessments, can enhance health equity and address the disparities associated with obesity management in low-resource settings. This review highlights several potential research avenues aimed at refining and validating BSSI across diverse ethnic and socio-economic groups both within Pakistan and internationally. Longitudinal studies assessing the relationship between changes in BSSI and health outcomes over time, as well as investigations into the socio-cultural factors influencing body composition, are essential for solidifying the role of BSSI as a critical metric in obesity research and management. Additionally, the integration of digital technologies for real-time BSSI monitoring presents an exciting frontier for

advancing personalized healthcare strategies aimed at obesity prevention.

The BSSI offers a promising avenue for refining obesity assessment, which is vital in combating the growing epidemic of obesity and its associated health complications. As the body of research supporting the BSSI continues to grow, it is imperative that healthcare practitioners, researchers, and policymakers work collaboratively to leverage its capabilities for a more nuanced understanding of obesity. Such collective efforts can lead to more informed health policies, effective intervention strategies, and ultimately, better health outcomes for diverse populations grappling with the challenges of obesity. The ongoing evolution of obesity measurement tools, such as the BSSI, signifies a vital shift towards a more comprehensive and equitable public health framework that addresses the complexities of obesity in a culturally sensitive and scientifically robust manner.

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Review

Juxtaposing overpopulation, depopulation, and population optimum paradigms in the context of the Earth carrying capacity

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Abstract: Studies on the threat of overpopulation of the Earth have been, as a rule, closely related to optimum population studies. At the same time, studies on depopulation have been conducted entirely separately. This paper juxtaposes the main currents of research on these three issues, trying to find an answer to the question of whether the ideas of global overpopulation and local underpopulation can be reconciled on conceptual grounds. The main research method was an in-depth analysis of scientific texts on the three concepts mentioned above. It has been proposed, first, to come to terms with the irreversibility of demographic changes accompanying social change, and second, to appreciate the role of migration as a balancing factor reconciling the demands of proponents of both extreme concepts. The latter points to a research field that has been poorly marked in the literature, the subject of which should be the analysis of the possibility of balancing local population surpluses and shortages by means of migration processes.

Keywords: overpopulation; depopulation; population optimum; sustainable population; carrying capacity; migration

1. Introduction

The issue of the speed of growth of the world's population has troubled humanity since time immemorial. It was pondered by ancient Greek, Roman and Chinese thinkers alike [1,2]. The roots of modern scientific thought on overpopulation can be traced to Malthus' most famous work, An Essay on the Principle of Population [3]. Its modern reflections are the reports of the Club of Rome [4] or Ehrlich's widely cited *The Population Bomb* [5]. The common denominator of these works is concern for the living conditions of future generations, to whom the overexploitation of resources will leave a damaged environment.

Also dating back to antiquity are considerations about under-population of certain areas, with explicit pro-population policy pursued by Caesar Augustus as an example [6]. In the Middle Ages up to the Enlightenment, many European monarchies introduced laws to promote population growth [7], and some states continued these measures before WWII [8–10]. The rationale was usually the belief that larger population was advantageous due to increased military potential and economic development opportunities. Even today many countries implement pro-population policies in order to halt population decline or reduce the population ageing rate [11–15].

Simultaneous implementation of demands of both sides is not possible. The first pursue population reduction, while the second desire its increase.

Perhaps an effective attempt to reconcile the above contradictions could be the

concept of the population optimum, according to which there is such a population size of the Earth that will keep the long-term environmental equilibrium, while allowing its human inhabitants to develop in a social sense and live good life [16].

Confronting the above three concepts could lead to an indication of the need to pursue one of the postulated directions—reducing population or stimulating its growth—in order to achieve optimal population. The operational goal of this paper is to juxtapose the results of research on the three strands and to critically analyse selected texts. Expectedly, this will make it possible to answer the question of whether mankind should take measures to reduce population or to stimulate its growth.

2. Theoretical framework

Scientific works whose authors consider the Earth's population too large in relation to the planet's carrying capacity usually ignore the fact that there are works proving the need to stimulate further population growth. It can be attributed to a different perspective and differently defined goals. Those anxious about depopulation are focused on political, economic and social consequences and usually work within the dominant economic growth paradigm, while those concerned with overpopulation are focused on the idea of environmental carrying capacity or environmental sustainability. Development in the spirit of respect for the latter is usually understood as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [17] (p. 16), where balance between the environment, economy and society is emphasised [18–20]. In this context, a sustainable population can be understood as one that will allow nature and humans on Earth to operate undisturbed in the long term.

Among works combining considerations on both threads is the work of Kuhlemann. She describes concerns about population decline and ageing as 'primal' and 'tribal' while finding the answer to the economic and social problems of today's world in rejecting "*primitive rhetoric of irrational fears about population degrowth and aging ...*" (p. 187). These authoritative statements do not leave much room for discussion.

Daily et al. [21] express themselves in similarly harsh terms. The Earth's population reaching 5.5 billion at the time of their work was too large, and the Earth's capacity was exceeded. They comment the works proving that the Earth can support 150 billion people stating that these "*(...) assertions are based on preposterous assumptions, and we do not deal with them here*" (p. 470).

The bibliographic search revealed no scholarly work that would juxtapose these contradictory considerations in a balanced way. In the face of hundreds of thousands of papers dealing separately either with depopulation or with overpopulation this is surprisingly few—a refseek.com search indicates 237,000 documents on "depopulation", 382,000 papers on "overpopulation" and 13,300,000 documents on optimal population, while a combination of these three words yields only 12,600 texts. Papers that touch both overpopulation and underpopulation in most cases either search for optimum population of the planet, or aim at finding a solution for future worldwide ageing [22,23]. Not a single paper was found that conceptually confronted all three concepts. Perhaps this shortage is the result of fundamental differences in approach

and differently defined aims. After all, some view overpopulation as a problem for nature, while others for human well-being. For this reason, all three concepts will be presented in sequential order and discussed in the next section.

3. Results

3.1. Overpopulation

The fear of overpopulation has accompanied mankind since ancient times. Its expression was manifested in numerous attempts to determine the optimal population size, and then to eliminate excess population by physically eliminating selected categories of people [24]. In the Middle Ages and modern times, ideas of population control were also common and they generally led to the conclusion of the need to reduce the population size [25,26].

Contemporary consideration of overpopulation begins with an attempt to define the term in the spirit of academic rigor. The common denominator of various definitions may be that it is a population that exceeds a size calculated according to selected criteria [27]. The choice of criteria varies widely. Often the starting point is the well-known equation $I = PAT$, indicating the magnitude of human impact on the environment as the product of Population, its Affluence level, and level of Technological development [28].

Daily et al. [21] used the amount of energy consumption as a proxy variable of human impact. They concluded that the Earth could safely support 2 billion people. Pimentel et al. [29], using the criterion of agricultural areas, arrived at 3 billion people, while Pimentel et al. [30] indicate that only 2 billion people can live at European-like level. Dasgupta and Beard [31] give two surprisingly different numbers: 2.4 billion and 80 billion, as they adopt two different ethical assumptions of interpreting what is good. We can find further estimates in the works of Barney [32], Keyfitz [33], Demeny [34], Hardin [35], Holden [36], Cohen [16,37], Dixson-Declève et al. [38] and many others.

Many authors recognise that there is no way to objectively determine the optimal population, so they turn to the search for the maximum sustainable size. Lianos and Pseiridis [39] assume that the ecological footprint to biocapacity ratio should be like 1:1, because only then we can maintain long-term sustainability. They derive between 3.1 and 7 billion people, depending on the level of production. Lianos [40] obtains 2.5 billion people, using similar assumptions. Tucker [41] gets 3 billion, hedging this figure with the need to re-naturalise large areas and making optimistic assumptions about technological development. O'Neill et al. [42] and also Callegari and Stoknes [43] emphasise the importance of intentional reduction of social inequality to achieve long-term sustainability, from which it can be deduced that the latter is to a large extent a political and not technical problem.

A comprehensive summary of estimates of the Earth's capacity can be found in Rosset's [44] multi-threaded work. He recalls that in the 19th century the Earth's maximum sustainable population was put at 5–6 billion people. By mid-20th century, it dropped to 0.5 billion, and then rose to 2.2 billion, 8, 9, 15, 18, 27, 47, 50, 130 and finally 157 billion.

The clear majority of contemporary estimates point to values much lower than

the planet's current population, and to negative consequences of the status quo. Lianos [27] speaks of living at the expense of future generations, while Dasgupta and Dasgupta [45] emphasise imminent collapse of a system unfit for regeneration. Pimentel et al. [29] warn about condemning "*(...) future humans to a lifetime of absolute poverty, suffering, starvation, disease, and associated violent conflicts (...)*", while Bajaj and Stade [46] claim the need to challenge pronatalism, which they perceive to be the key to sustainable population.

Estimates indicating that further growth of human population is not a threat, because we still have a safe supply of resources and can continue to expand, are few. Some explain their approach using the concept of classical utilitarianism. It assumes that the goal is to maximise the sum of production of goods and services in the world, which is the good by itself [47]. Increasing the Earth's population results in an increase in total production, which is good, despite the unavoidable deterioration of the average standard of living.

3.2. Depopulation

Population decline also raises concerns, but mostly at regional scale. Declining birth rates lead to decline in the size of successive age cohorts, which undercuts the economic base over time, causing the working-age population to shrink, and accelerates population ageing processes [44]. It gives rise to negative economic consequences, particularly for the labour market and retirement pension systems. This process intensifies with outmigration, as the most mobile middle-aged people leave.

Projections pointing to radically lower future population of many countries raise fears about the future. Vollset et al. [48] estimate that populations of most highly developed countries (HDCs) will fall, sometimes even by half. Hidekazu [49] (p. 1), facing earlier projections for Japan's population falling to 50–60 million by 2100, says: "*Japan's social vitality and the vital forces of the state will be debilitated, jealous political rivalries will be unleashed, and people will lose confidence and become trapped in a spiral of pessimism and nihilism... It must not be allowed to happen*". In Poland, for which Vollset et al. [48] forecast a decline from 38 to 15 million inhabitants, serious online portals scare their readers with statements such as: "*One should sound the alarm!... Demography in Poland in the 21st century will be one of the worst in the world*" [50], "*The worst is ahead*" [51], or *"Fatal data. CSO confirms that we are facing a demographic disaster"* [52].

Public administrations in many countries have tried to counteract the threat since decades. By 2003 thirteen OECD countries claimed to have policies regarding fertility [53,54]. Globally, by 2005, approximately 30 countries had total fertility rates (TFR) below 1.5 Achieving TFR of 1.7 and implementation of prudent migration policies to compensate for population shortages was considered possible.

Also today, many countries implement similar policies. Sometimes these are planned actions resulting from adopted strategies, while sometimes they are a collection of individual impacts on society and the economy, not connected by any conceptual thread, but leading in a similar direction. It was in this vein that the report *Czech Demographic Success* [55], prepared in Poland and glorifying the effectiveness of Czech demographic policy, was referred to during its first public presentation by a

representative of the Czech embassy, who said that in his country no one knew that they had a demographic policy.

Advocates of regional population growth unanimously ignore the very existence of the opposing trend for the world, as if they did not notice that an increase at regional level resulting from natural growth always translates into an increase in the world population. They also fail to note that the growing pronatalist pressure may often have clearly oppressive character and undermine reproductive autonomy [46].

3.3. Population optimum

In ancient times one can find clear indications of the need to control population size. It was justified by pointing to the optimal population, a golden mean between the extreme states of underpopulation and overpopulation, supposedly corresponding to the maximum achievable standard of living [21,24,44,56,57]. The very existence of the extreme states was taken for granted.

Contemporary works on the subject often aim at calculating the population optimum. Computations are made for various spatial scales, from cities, to municipalities, regions, countries and the entire world [58–61]. Most often, they result in a specific number.

What population can be considered optimal? Thomlinson [62] believes that one that allows living at high standard. Too many people means too much pressure on resources, while too few means not being able to achieve economies of scale and reach a critical mass necessary for development. How then to indicate when the standard of living is optimal? According to Dasgupta [63], the starting point is the adoption of ethical foundation for the analysis: either average or classical utilitarianism. Average utilitarianism is a philosophical concept that assumes that further population growth is beneficial when, due to it, the average standard of living will continue to rise. Classical utilitarianism sets as its goal the maximisation of the sum of individual well-beings.

Parfit [64] reduces the above dilemma to the question: is it better to have fewer people living better lives, because a better life is better, or is it better to have more people, because each life is a value—assuming that these lives are worth living. Hence, we face the question of what is the relative value of quality and quantity. More transparently, is it better to live a shorter and good life, or a longer and barely worth living life? Option one is more tempting, and this means average utilitarianism and limiting the population size to optimum. The second option, although it also finds many supporters, is often rejected because of what Parfit [65] already indicated in his fundamental work and called “repugnant conclusion”, as it leads to almost infinite growth of population [66].

According to the dynamic optimum population theory, the optimal size depends on available resources, environmental conditions, and socio-economic variables, so it changes over time [67]. Additionally, it depends on the criteria adopted, so there may be many possible optima at any time, but they must all fall between the minimum viable population and the biophysical carrying capacity of the planet to keep living conditions of future generations at present level [21]. In this view, the relationship between population optimum and sustainable population is particularly clear, where

planetary boundaries define the limits of population growth [42,68]. Odum [69] states that the higher the level of development of a country, the lower its population optimum, because development translates to greater consumption and more waste. Answering the optimum question requires therefore answering the question of how we want to live.

There is no univocal answer to this question though. For this reason, many authors skip this phase of considerations and move on to calculations based on selected parameters, such as energy consumption, availability of farmland, human pressure on the environment, and others. Thus, when writing about the population optimum, many researchers de facto calculate the maximum population, or sustainable population.

Among the works that separate optimal from maximal values, the calculations of Lianos and Pseiridis [39] indicated that in 45 of the 52 countries they examined, the population should be reduced radically, with a global population reduction of 3.8 billion. Yet, it may be argued that they are more concerned with sustainable population than with optimal population.

Toney et al. [70] surveyed over 1200 researchers affiliated with the Population Association of America for their views on population issues. Nearly 97% stated that the rate of population growth was too high, while there was no agreement at all on the optimal population. Indications of the optimum for the United States ranged from 25 thousand to 3 billion people, while those for the world ranged from 100 million to more than 80 billion.

In brief, there is no consensus on the key questions: what criteria to adopt, what boundary values of indicators to accept, or what standard of living is the goal. The result is a huge scattering of results, which in itself is a clear indication that this analysis cannot be objectified.

4. Discussion

We will discuss the above three concepts together, in four sub-sections, so that we can confront the assumptions presented above in several different fields.

4.1. Simplifications

Describing any complex issue synthetically involves making simplifications. The key feature of each step of simplifying reality is to preserve the most important features of the examined phenomenon, despite the increasing level of information aggregation. In other words, the answer to the question of whether—despite the simplification—the picture being drawn is still true, although it is becoming increasingly blurred and fuzzy, should invariably be ‘yes’.

Dasgupta’s [63] well-known essay assumes that everyone is identical—ergo, they live and will live at identical levels. The justification is the laconic “for simplicity” [63] (p. 8). Parfit [64] (p. 146), making the assumption of people’s equality, explains it by the need to avoid “irrelevant complications.” It is hard not to notice that such simplifications ignore cultural differences, expectations regarding offspring, and different needs of the labour market in countries at different levels of development. They also ignore individual preferences and expectations regarding living standards, nutrition habits and family size. Thereby the assumption of lack of inequality may be

regarded as conceptually flawed.

Another simplification is the assumption that it is common that a woman or family can decide how many offspring to have. The percentage of women using modern contraception with medical and technical means ranges from 0.9% in South Sudan, through 56.5% in India and 80.5% in China, up to 81.6% in Finland, with the world average at 55.7% [71]. It indicates that the habit of family planning is still not widespread. The average unmet need for contraception in less developed countries (LDCs) is 21.7% [72] and it does not add up to 100 percent with the previous number in any country. For example, in South Sudan the total is 27.2%, in India 65.9%, and in China 82.8%. Hence, many women neither use nor report a need for contraception. Moreover, the expected number of children exceeds four in at least 20 countries in the world; given the limited availability of data it can be assumed that the real number is higher [73]. There is a profound variation in socio-cultural norms and woman's position in the family and society behind these numbers. Accordingly, the expectation that humanity will en masse reduce its own fertility due to planetary-scale constraints does not take into account either socio-cultural factors [74] or the inability to comply with these constraints.

Dasgupta [75] assumed also that people start working at birth and work until they die. He writes: "*I apologize for this assumption, which is bad (...) I have retained it because of its obvious analytical advantage*" (p. 297). One can't help but ask the question: does the submission of an apology for the flaw justify conducting a complex analysis on a biased foundation? In the same work, the author assumes that technical progress does not exist. Since the underestimation of progress as a factor significantly affecting reality is common, we will look at it more extensively in the next section.

4.2. Technological advance

Considerations regarding impact of technology on population optimum often start with a search of a proxy variable representing population. The question of the space required for living is often reduced to the question of how much energy humanity needs, and comparing it to the total amount of energy available. This way energy consumption has become a measure of human impact on the environment [21,28].

It seems that this take needs reconsidering. It is due mainly to the increasing share of energy production technologies and consumption patterns that are largely neutral to the environment, like renewable energy sources, growing electric car markets, and many more. They are all gradually decreasing humanity's dependence on fossil fuels. If humanity stops using them, treating energy consumption as a measure of overall consumption will no longer make sense—just as it doesn't make sense today to treat the world's volume of horse feed production as a measure of capacity for land transportation.

As for now, discrediting technological progress as a factor shaping the number of people the Earth is likely to accommodate, or assigning it a solely negative role, is widespread. Lianos [27] (p. 82) writes that "*arguing that technology can solve the problem of ecological disequilibrium is the same thing as arguing that one can step out of their shadow*." For Kuhlemann [76] (p. 182), technological progress facilitates

exploitation of raw materials, so it contributes to increased consumption, and the future will not change anything, because our actions "*(...) do not stop being unsustainable because things might change in the future*". This may probably be due to the belief, stemming from the groundbreaking work of Jevons [77], that an increase in the efficiency of energy-consuming devices will cause an increase of total energy consumption. Takkinen and Pulkki [78] emphasise that technology is often at odds with sustainability, while Abirami and Keerthika [79] note that rapid technological change can outpace society's ability to respond, creating new policy and sustainability risks. Even those who notice a potentially positive impact of future technological inventions, usually postulate that calculations of the population optimum should be guided by changes in technology that are known today and foreseeable (compare [21]).

Kuhlemann [76] (p. 185) writes also that she is "*not aware of any credible proposals for feeding a world of 16 billion or more*." This shifts the centre of gravity of the discussion from energy to food production, which been addressed since ancient times [1,6,25,26,33,80,81]. Modern thinking on this issue is undisputedly dominated by Malthus [3]. Despite the widespread criticism of his concept [82–86], neo-Malthusianism continues to dominate the popular consciousness.

For the record, it should be noted that there are works whose authors recognise positive impact of technological progress or general economic progress on planetary carrying capacity and argue that technical and social change combined with a focus on sufficiency could give an equally good life to 7 billion [38,42].

It is worth noting that the authors of the most of above analyses tacitly assume that they are able to accurately assess whether or not future inventions will manage to save humanity from trouble. Yet, as Taleb [87] writes, in order to predict what will happen in the future, one must anticipate technological innovations that are fundamentally unpredictable. We don't know what we will invent—if we knew it now, we would have invented it by now. Therefore, it is appropriate to assume that technological developments will lead to the invention of new solutions we cannot imagine today, rather than to assume their stagnation. It is equally appropriate, however, to assume that the inventions we expect won't come soon enough, that they won't produce the desired results in a short enough time, or that unforeseen side effects of new technologies will cause more harm than good on a planetary scale. The concerns of those reluctant to consider future inventions in their forecasts are summed up by Bregman [88] (p. 232): "But the inability to imagine a world in which things are different is evidence only of a poor imagination, not of the impossibility of change".

Yet, detailed considerations of technological progress are definitely beyond the scope of this paper, so this discussion should rather be regarded only as an attempt to show that—given the existence of uncertainty about future events—both excessive pessimism and excessive optimism are inadvisable. Technology should neither be attributed the qualities of magical silver bullets, nor apparent increase of human impact on the environment.

4.3. Fundamentals

Pimentel et al. [29] (p. 363) write that: "*overpopulation, maldistribution of resources, and environmental degradation are causing serious malnourishment and*

poverty throughout the world." Combining these five terms—three causes and two effects—in one sentence makes cause-and-effect analysis difficult, so let's look at them more closely. If poverty is the lack of sufficient resources to meet needs, then malnutrition is a result of poverty—a wealthy person will not be malnourished, because by definition they can afford to meet more than their basic needs.

Can overpopulation be a cause of poverty so that it later translates into malnutrition? If we understand overpopulation in a classical way as exceeding the maximum population that an area can feed at its maximum production, then Singapore or Monaco are overpopulated much more than Somalia or South Sudan. At the same time, in the first two countries poverty is marginal and malnutrition is essentially zero, unlike the second pair of countries. In the age of the global market no country needs to produce food in order to feed its people. Ergo, considering overpopulation within national borders has lost its raison d'être (compare [39,89]). Such considerations would have made sense in prehistoric times, when each community had to feed itself, which had an overwhelming effect on the population size that could live in an area.

Global food production today is greater than the sum of food needs, and the number of the obese is far greater than the number of the undernourished [90]. Despite this, numerous authors argue that providing food for 1 person requires 0.5 hectares of agricultural land, so there should be maximum of 3 billion people on Earth (e.g., [29]). 30 years after this publication, there are some 8 billion people on Earth, and the number of the hungry has been decreasing consistently. In 2022 about 735 million people faced hunger [91]. The problem, therefore, is not a shortage of food, but poverty, which does not allow many to buy food. The ability to purchase food is a derivative of both buyer affluence and food prices shaped by many factors, including the price of food inputs, climate change, food preferences and many others. However, these considerations, along with analysis of causes of poverty, are far beyond the limits of this paper. It is clear that on a planetary scale there must be a physical limit to the amount of agricultural production possible. Yet, today global overpopulation considered from the perspective of the ability to feed the human species does not exist (see also [38]).

In their calculations many authors for years tacitly assumed that the sum of resources available on Earth was fixed [64]. This corresponded to the static theory of resources, which assumed that the amount of resources at our disposal would never increase, since we had no guarantee of future findings or inventions. After all, there is a competing, dynamic resource theory that assumes that we will continue finding new resources or new ways of collecting them, as it used to be in the past. The key resource is human knowledge and skills, because they determine our ability to replace a depleting resource with another one [92], see also current an example of application of dynamic concept by Edwards et al. [93]. Thus, any calculation of the availability of food, raw materials or other factors shaping the Earth's future population should take into account changes in their supply, not just demand for them. The choice of resource theory—static or dynamic—is crucial to the calculation. As carrying out reliable calculations in the absence of future data is not possible, many works refer to static theory and known resources.

A conceptual starting point for all calculations is that the environment must be able to support people living either at the optimal level—for the population

optimum—or at the limit of the acceptable level—for the maximum population. Already here, variables of absolutely fundamental importance to the entire analysis appear to be impossible to agree on unambiguously: where is the boundary between acceptable and non-acceptable standard of living? Is this 1000 kilocalories per day, because it allows survival, or perhaps 1800 or 2500 kilocalories? Is it 500 kWh per year per household, or is 250 kWh enough? Or can we do without electricity, like nearly 13% of the planet's population [94]? Is public transportation enough, or a bicycle, or is at least one car in a family an acceptable minimum?

The number of such questions is unlimited. Their common denominator is the unresolved problem of what the welfare subsistence rate actually is. Dasgupta [75] discusses whether it is a level of consumption below which someone is all the same whether they live or die, or whether they were born or not. Alternatively, is it the level of welfare that parents want to guarantee for their child before they conceive. It is impossible to answer any of these questions directly (compare [95] or [96]). The boundary for each of us may lie elsewhere, which depends on individual expectations, place where we live, the intrinsic diversity of the community in which we live and many other conditions.

Parfit [64] infers that a shorter life at a high level ("Century of Ecstasy") is better than a longer life at a low level ("Drab Eternity"). However, it still does not help find minimum acceptable or optimal values of happiness or well-being. A population that is optimal from one perspective may not be so from another. Additionally, a change in circumstances changes the optimum [97]. Thus, it is impossible to point to any minimum or any optimum, in the absence of objective reference points.

We can come to similar conclusions by studying the changing approaches to demographics in different countries. Hidekazu [49] provides a detailed analysis of how Japan's population was alternately considered too small or too large during the short period of 1918–1970. Governments changed social policies once allowing abortion, once banning it, once encouraging emigration, and once encouraging childbearing. It was only in the late 1980s that Japanese experts admitted that the fertility decline was permanent. The same was true in Poland, where in the post-WWII period both increases and decreases in birth rates were alternately commented on as either favourable or unfavourable for society and economy [44,98].

4.4. Solution proposals

Despite the widespread awareness of the impossibility of establishing fundamental assumptions, calculations of the optimal and maximum sustainable population show up one after another. Usually estimated numbers are much smaller than the Earth's population today, so the proposals demand a population reduction and then follow-up with solutions to achieve it.

Dasgupta [75] (p. 296) claimed that "*(...) perfectly egalitarian distribution of the generation's consumption allotment is the best distribution*." The examples of the Soviet Union, Cuba, North Korea, Venezuela and many others amply demonstrate that it is impossible to achieve equality at a high level of life—decreed equality in practice translates only into widespread poverty.

Kuhlemann [76] points to one-child family as the ideal. Expecting a 2 + 1 family

to become the world standard would probably require a world government to address the problem of overpopulation, as postulated by Lianos and Pseiridis [39]. Lianos [27] (p. 75) proposes that each family be allowed to have only 1.5 children. The means to achieve this would be "*(...) the creation of an international market for human reproduction rights,*" in which each couple would have three saleable half-child allowances. The plan would cut the world's population in half within 3–4 generations. China's One Child Policy project, despite different means, had similar goals. The country withdrew from the policy in 2016, and in 2021 launched a campaign promoting three child families, in the face of a looming demographic crisis [99]. In Singapore, where the TFR was intentionally limited and has fallen from a record 7.68 in 1939 to 1.27 in 2003, and presently remains below the 1.3 mark despite all government efforts and incentives to increase it [100]. The creation of a reproductive rights market could end similarly—first with a diagnosis of the adverse effects of the solutions adopted, and then with a failed attempt to reverse the unfavourable trend. As these examples show, state interference in natural demographic processes can lead to imbalances that are difficult to regain.

Are there any other solutions? We will look at this in the next chapter.

5. Alternative solutions

There is a clear contradiction between the desire to reduce the world's population, and to stimulate its growth at regional level. If we were to accept the validity of both of concerns—for future generations and for economic stability—then we should focus our efforts on finding solutions that can reconcile these goals. Since there is room for population increase in countries facing depopulation, then—according to the laws of physics transferred to society—a surplus should naturally shift to a place where there is shortage. It is migration that answers deficits in HDCs' labour markets, not an attempt to raise fertility rates. The efficacy of the latest is often questioned (see [101–107]) and the fertility has not reached replacement level of 2.1 in any of the countries that implemented pro-natalist policies in last 20 years [12].

HDCs need a steady supply of cheap labour, and a set of measures to cushion the effects of ageing. Although the idea of saving the demographic and economic structures of HDCs by increasing immigration from LDCs is debatable, at the same time it is most often pointed out that at least in some sectors of the labour market immigrants are able to reduce the problem of labour shortages (cf. [108–113]).

At the same time less developed countries (LDCs) are a potential source of millions of people willing to migrate. These countries benefit from the emigration of their citizens, and sometimes even urge them to emigrate [110,114–117]. The main benefits are remittances, increase of emigrants' human capital, investments in the country of origin after re-emigration, and in some cases also reduction of malnutrition of local overpopulation.

The needs of HDCs and LDCs seem to find common ground in international migrations. While in many LDCs there is surplus of population, as stated by Lianos and Pseiridis [39], the HDCs needs it.

Despite advantages of immigration for the HDCs economies, many governments consider it a problem rather than a solution, exposing its socio-cultural negative

outcomes and allowing for public resistance against immigrants [118,119]. Balancing between the expectations of the economy and employers, on the one hand, and workers and the general public, on the other, is driving some governments to declare non-acceptance to admitting immigrants and to admitting them the same time. In 2022 alone, Poland granted 700 thousand residence permits to non-EU nationals, the highest number in the entire European Union, despite government narrative clearly opposing immigration [120,121].

6. Conclusions

Proponents of overpopulation concept argue that there are far too many people on Earth today. Proponents of population optimum, most often using similar tools and arising from the same ideas, usually conclude that the optimum has been exceeded. Proponents of underpopulation, focusing on a more local level, ignore fears of overpopulation of the planet and point to the need for population growth, particularly in HDCs. At the same time, they are discredited by proponents of both previous concepts.

Faced with the impossibility of determining where the world's population optimum or maximum is, this text has proposed coming to terms with the irreversibility of demographic changes resulting from economic, social and also technological change. It is also postulated to appreciate the role of migration as a factor potentially reconciling the demands of proponents of both extreme concepts. Local population surpluses could thus find a place where there are shortages. Therefore, both the demands of those who signal the need for population reduction in some countries and those who postulate population growth in other countries would be met. This conclusion opens up a new field of research in which research on overpopulation or underpopulation can be combined with research on the determinants of migration and migration policies to meet the needs and demands of both sides of the debate.

The conclusions drawn from the above analysis have certain limitations. The fact that it has not yet been possible to define the optimal or maximum world population in a universally accepted way does not mean that this will not be achieved in the future. If this happens, then the conclusions drawn from the analysis presented in this text would be of limited use. Furthermore, treating migration as a remedy for the problems of ageing societies in HDCs, shrinking working-age cohorts, or population decline in general has been severely criticised in the UN report already cited [109]. If, therefore, migration cannot solve these HDCs' problems, is there any chance of solving the problem of local overpopulation and local population shortages with migration? Answering this question undoubtedly requires detailed research based on numerical analysis. This task goes beyond the scope of this paper and thus points to the direction of further research.

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