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IMPACT ASSESSMENT REPORT OF "SUNNY SCHOOLS" INITIATIVE

2026







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Acronyms

ARI	Acute Respiratory infection
CCRI	Children's Climate Risk Index
DiD	Difference in difference analysis
EU	European Union
IARC	International Agency for Research on Cancer
OSF-WB	The Open Society Foundations– Western Balkans
SE	Standard Error
WASH	Unsafe water, sanitation and hygiene
WHO	World Health Organization

Executive Summary

The Sunny Schools Initiative (2021–2025) was implemented in selected schools across Albania with the aim of promoting energy democracy by transforming public schools into energy-neutral entities – through the development of photovoltaic rooftops. The intervention focused primarily on the installation of solar panels in schools located in different districts, including Dibër, Elbasan and Shkodër. This intervention is expected to influence also the health and wellbeing of children and local communities in the intervention districts.

This impact assessment was based on the OECD project's evaluation criteria as relevance, effectiveness, efficiency, impact and sustainability. The methodology employed mixed methods including primary quantitative data collection from intervention schools, control ones, health care operators and focus group discussions with teachers and interviews with medical staff working in the respective school communities. Difference in difference analysis (did) was applied to measure the differences between schools' absenteeism among intervention and controls schools before and after the installation of solar panels, while routinely collected health-center data were analyzed to explore morbidity patterns before and after implementation.

Although the intervention is still at its early stages, overall, the findings indicate that the initiative addressed important infrastructural and environmental needs in participating in schools. Teachers and health professionals consistently identified reliable heating, hot water, improved hygiene conditions and energy availability as important needs. In schools where the photovoltaic systems were functional and connected to appropriate supporting infrastructure, participants reported improvements in classroom warmth, hygiene, comfort and the general learning environment. These benefits, however, were not uniform across schools. Their realization depended substantially on the availability and condition of complementary infrastructure. In several locations, limitations such as inadequate heating systems, poor insulation, outdated electrical installations, boilers and insufficient hot-water or ventilation systems restricted the extent to which the photovoltaic installations could translate into improvements in the school environment. In some locations, the systems were not yet operational at the time of assessment and were therefore excluded from the quantitative health-impact analyses.

On the other side, medical staff observe fewer respiratory complaints and believe health effects will accrue over time if schools further upgrade heating and ventilation.

The difference in difference analysis shows a significant decrease of school absenteeism in “Ptoleme Xhuvani” school (-15.6, P=0.001) and “Dëshmorët e Prishtinës” School (-14.09, p=0.025) in comparison with their control schools “Sulë Misiri” in Elbasan and “Branko Kadia” in Shkoder based on their respective intervention years 2022 and 2024. The observed decrease of school absenteeism is an important impact associated with the intervention with expected long term impact in more improved education, simultaneously supporting working parents.

The quantitative analysis demonstrated statistically significant reductions in the morbidity levels of the children 5-15 years old living in the intervention schools’ areas:

- *ARI incidence; Diarrhea incidence; Allergy incidence.*

Specifically:

- *ARI incidence was estimated to be 17% lower during the post-intervention period (IRR = 0.83)*
- *diarrhea incidence was estimated to be 16% lower (IRR = 0.84)*
- *allergy incidence was estimated to be 37% lower (IRR = 0.63)*

Nevertheless, these findings inform on the general time trends of these diseases for the periods before and after the intervention in the school population areas are covered by the health care centers. The interventions and their expected improved health and wellbeing outcomes may be one of many factors affecting these trends.

Even though, the data do not provide strong evidence that the **solar panel interventions alone** reduced morbidity levels regarding acute respiratory infection, diarrhoea, and allergy. Solar panel interventions may contribute indirectly to better health and wellbeing, but any sustained health intervention seem to be linked to broader infrastructural improvements to produce measurable reductions in morbidity. The qualitative evidence demonstrates also the nuanced implementation experiences. In some schools, especially in Elbasan and parts of Shkodër, teachers and medical staff described better handwashing conditions, warm water, improved comfort, calmer pupils, and better concentration. In other sites, especially in Dibër, Bulqizë, Cërrik and Belsh, participants said the panels were not yet connected, not yet functional, or the intervention is underway.

Overall, the intervention represents a promising model for integrating renewable energy solutions into educational settings while contributing to improved school environments, environmental awareness, and long-term institutional benefits. However, the evaluation demonstrates that solar panel installations alone are insufficient unless combined with broader infrastructural improvements and sustained institutional commitment. Overall, the panels improved conditions if schools address the contextual constraints. Key recommendations are to integrate follow-on upgrades (heating systems, water/air filters, maintenance) and strengthen financial/governance arrangements so that electricity savings are reinvested in schools.

KEY ACHIEVEMENTS

Solar Power for Healthier Schools, Brighter Futures

Empowering schools with clean energy and improving the health and well-being of children.



19
BENEFICIARY SCHOOLS
across Elbasan, Shkoder and Diber

11,158
BENEFICIARY CHILDREN
with improved learning and health conditions

Clean, reliable solar energy installed in schools to create healthier, more productive learning environments.

BETTER SCHOOL ATTENDANCE

Difference-in-Differences (DiD) Analysis

The DiD analysis shows that the intervention contributed to reductions in school absenteeism in selected schools.

Ptoleme Xhuvani School, Elbasan
-15.6
DiD COEFFICIENT
p = 0.001*

Dëshmorët e Prishtinës School, Shkoder
-14.09
DiD COEFFICIENT
p = 0.025*

Overall, the DiD analysis suggests that the intervention may have contributed to improvements in school attendance, with a general trend toward reduced absenteeism across most schools.

QUALITATIVE ACHIEVEMENTS

- Improved classroom comfort with better lighting, heating and ventilation.
- Students feel healthier, more energetic and more motivated to attend school.
- Teachers report better teaching conditions and increased engagement.
- Reliable electricity supports digital learning and school operations.
- Stronger awareness of environmental protection and sustainability.
- Stronger community pride and ownership of school improvements.

OUR IMPACT IN NUMBERS

BETTER ATTENDANCE
Significant reductions in absenteeism in 2 schools and positive trends in others.

HEALTHIER ENVIRONMENT, BRIGHTER FUTURES
Clean energy creating lasting benefits for children, schools and communities.

3 KEY HEALTH OUTCOMES IMPROVED
Reduction in ARI (17%), diarrhea (16%) and allergy (37%) incidence after intervention.



BUILDING A SUSTAINABLE, HEALTHY FUTURE

This project demonstrates how clean energy in schools can improve child health, increase attendance and support quality education for a better tomorrow.

Introduction

Theoretical background on how climate change influences children's health

The WHO has presented substantial evidence about the disproportionate vulnerability of children in response to climate change. The diseases likely to be potentiated by climate change are already the primary causes of child morbidity and mortality, including vector-borne diseases, water-borne diseases and air-borne diseases.

Research shows that the annual death rate of children under five years old could double in low-income countries by 2050 compared with the decade 2005–2015, in a scenario without effective mitigation of rising carbon emissions (Chapman et al). The increase may undermine gains made in other areas of child health and slow the global development progress towards the UN's Sustainable Development Goals, which seek to end preventable deaths of children under-five and reduce under-five mortality.

Increasing rates of air pollution include particulate matter from wildfires, smoke and airborne dust linked to climate change, as well as ground ozone, pollens and spores. As air quality deteriorates, rates of respiratory and cardiovascular morbidity and mortality increase, including asthma exacerbations (Guarnieri et al). Air pollution is an environmental cancer risk that the International Agency for Research on Cancer (IARC) classified as a "group 1 carcinogen" in 2013.

Children's faster respiratory rate, pulmonary immaturity and the time they spend outdoors make them more vulnerable to poor air quality than adults. Exposure to air pollution during the prenatal period and early childhood can be particularly dangerous.

The distribution of disease-carrying vectors is expected to be altered by climate change, whereas the transmission and survival of infectious pathogens will be influenced by changing weather patterns. Infectious diseases take a disproportionately high toll on children in general, and socioeconomically vulnerable children.

A systematic review of the association between temperature and all causes of diarrhea suggested that climate change could be responsible for a substantial portion of diarrhea cases. Specifically, the prevalence of Escherichia coli, Cryptosporidium, rotaviruses and parasites increases with higher temperatures. Rural areas suffer from higher diarrhea incidence rate among children due to the use of unsafe drinking sources and limited hygiene. Temperature seems to be the most important weather variable associated with diarrhea.

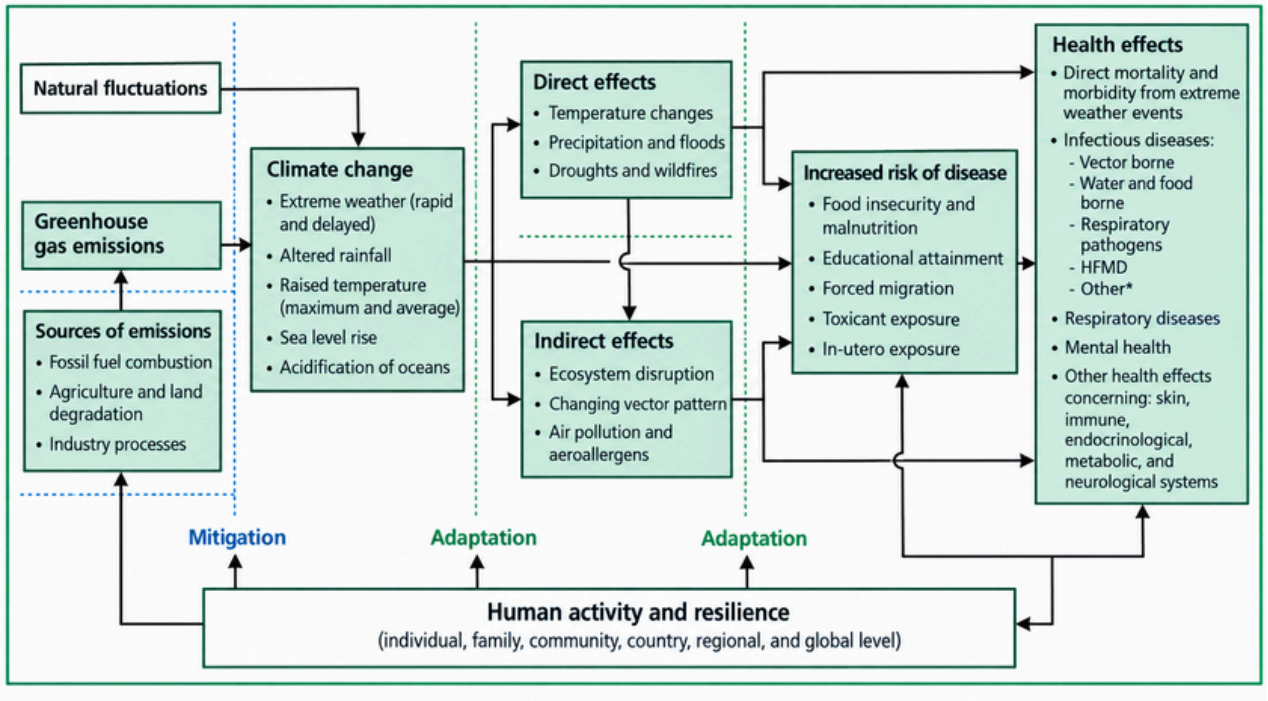
On the other hand, climate variability in the form of increased rainfall and humidity correlates with a higher risk of contracting bacterial and viral lower respiratory tract infections among children. A changing climate could also affect the geographical range of other infectious diseases, from mumps to bacterial meningitis, varicella viruses and parasitic diseases such as schistosomiasis (Hellden et al).

Unsafe water, sanitation and hygiene (WASH) remain important factors for preventable diseases and deaths. One in 4 deaths attributed to these factors worldwide is recorded among children under 5 years old. Increasing climate threats, including water scarcity, heat waves and flooding, can threaten the still fragile situation of WASH (UNICEF).

UNICEF has considered climate crises in its 2021 report as a child rights crisis and identified seven potential crises created by climate change and environmental degradation.

A recent scoping review published two years ago in Lancet proposed the following conceptual overview of how a changing climate could affect child health. The proposed framework details how greenhouse gas emissions led to a changed Earth system with higher temperatures, altered rainfall, a rise in sea level, acidification of oceans and an increased frequency of rapid and delayed onset extreme weather events.

Figure 1: *Climate change and child health: an expanded framework (Hellden et al 2021)*



Children's Climate Risk Index

The Children's Climate Risk Index (CCRI) composite index is proposed from UNICEF as synthetic index that aims to measure child vulnerability to multiple climate and environmental stressors. It is a multisectoral model that seeks to represent a balanced view of the different sectors involved in the well-being of children, focusing on aspects that could contribute to, or aggravate, child deprivation in the context of climate-related and environmental shocks and stresses.

The index has a complex structure, bringing together a set of indicators across two dimensions; (a) exposure to climate and environmental hazards, shocks and stresses and (b) child vulnerability, coping capacity and capacity of society to deliver services.

The index is described thoroughly in the 2021 UNICEF publication "The Climate Crisis is a Child Rights Crisis: Introducing the Children's Climate Risk Index". In that report, Albania ranks 84 in a list of 163 countries with a children's climate risk index 4.8, with Central African Republic and Chad as most at risk and Luxemburg and Iceland as the countries with the least vulnerability. Albania scores relatively high in terms of risk from climate and environment factors (6.5), but relatively low for child vulnerability (2.5).

Summary of Children Health Vulnerability in the context of Climate Change in Albania

In the following matrix are summarized the predicted trends of health conditions among children in Albania under the influences of climate change.

Matrix 1: *Health conditions among children in Albania under the influences of climate change*

Conditions, risk factors	Current estimates	Potential influence of climate change	Estimations of additional burden of disease in relation to climate change scenario	Data sources
Mental health	The prevalence of feeling low, feeling nervous and irritable or bad tempered all the time or most of the time is over 15%, or around 100,000 children and adolescents in the Albanian population.	More frequent extreme weather events and disruption of socioeconomic factors increase young people's susceptibility to mental health illness in the form of depression, post-traumatic stress disorder and anxiety. Also, long-term behavioral effects are expected, increasing the risk of other diseases.	Both the prevalence of poor mental health and severity of episodes is expected to increase.	Data from national school-based surveys
Asthma	More than 20,000 children suffer from asthma. Every year in Albania, around 1,000 children are hospitalized for bronchial asthma treatment. 18% to 25% of children are sensitized to various allergens.	As temperatures increase, warmer air triggers ground-level ozone and smog, which are powerful air pollutants. Ozone irritates the lungs and may trigger asthma attacks. With global warming, the pollen season is getting longer, which can also trigger asthma attacks in some categories of children.	More new asthma cases are expected in the future. The exacerbation attacks may also be more frequent, increasing the need for specialized emergency care. Existing increasing trends from asthma and allergies will continue at least in the medium term, with increasing trends in hospital admissions and lost school days.	Data retrieved from hospital and PHC information system and limited population surveys

Respiratory	Air pollution attributable mortality for children under 5 years old is estimated at 0.12/100000, 5,500 to 6,500 children under 5 years old are hospitalized every year for respiratory conditions in Albania. For the category of 0-19 years old the number is around 9,000.	Climate change will further aggravate air quality, indirectly affecting respiratory health problems in children. Additionally, extreme weather events (including cold snaps) remain an important risk factor for the health of vulnerable children suffering from severe respiratory conditions.	The existing decreasing trend may be halted or even reversed in the case of scenarios with high air pollution and frequent weather extremes. The trend may even affect child mortality indicators through pneumonia-related deaths.	Data from health care information system. Estimates are also retrieved from WHO and Global Burden of Diseases project.
Gastroenteritis /diarrhea	Around 440,000 cases of gastroenteritis in children 0-14 years old were reported by healthcare providers in 2019, and around 32,000 in 2022. The rate is higher in the general population; 6.1% of children have diarrhea every two weeks during the year (estimated to more than 200,000 cases per year).	Higher temperatures are considered a risk factor as they favor the multiplication and spread of infective agents in drinking water, food and households. Additionally, floods can also disrupt water and sanitation systems, therefore increasing the risk for outbreaks of waterborne diseases.	There is consistent evidence demonstrating a tangible increasing risk from gastroenteritis and possibly infectious among children, in absence of mitigation measures. It can be estimated that 300 – 1,000 new cases of gastroenteritis per 100,000 children per year to be attributed to every degree centigrade increase. It can be translated to as many as 5,000 new cases every year in the coming decade. Hospital admissions and lost school days will increase in numbers. The severe and neglected diarrhea cases may also increase, potentially affecting child mortality trends.	Data from epidemiological surveillance and national population surveys.
Other Infectious/ vector borne diseases	Dozens of cases of leptospirosis, hemorrhagic fevers etc. are diagnosed and epidemiologically investigated every year by the Institute of Public Health.	Like most zoonoses, climate change is causing changes in the ecosystems and the habitat of vectors, including insects and rodents, responsible for spreading diseases.	A resurgence of some vector borne diseases is expected, while the risk of outbreaks will continue to threaten the lives of children.	Data from epidemiological surveillance and outbreak investigations.

Background of "Sunny Schools" Initiative

The Open Society Foundations – Western Balkans (OSF-WB) is a regional entity working in Albania, Bosnia and Herzegovina, Kosovo, North Macedonia, Montenegro and Serbia. The purpose and mission of OSF-WB is to inspire and enable open societies across the region through strategic presence and interventions in key regional and European spaces and priorities.

The Sunny Schools Initiative is an operational project by OSF Western Balkans promoting energy democracy by transforming public schools into energy-neutral entities – through the development of photovoltaic rooftops. The initiative is currently implemented in Albania, Serbia, Kosovo, North Macedonia and Bosnia Herzegovina. It prioritizes community-level renewable energy production and the establishment of energy communities.

Beyond financial gains, the initiative fosters community engagement by involving 32 municipalities in the Western Balkans, transforming schools into hubs of renewable energy production.

By developing small-scale photovoltaic social enterprises owned by public school stakeholders, the initiative aims to widen the income base for schools, reinforce self-governance, and enhance social inclusion in education.

Methodology of the project

By empowering local communities, enhancing education and accelerating the green transition, Sunny Schools contributes to the development of a local energy economy, distributing energy transition benefits more fairly, whilst strengthening the resilience of public schools in coping with emergencies. By boosting community participation in energy governance not only makes schools self-sufficient in energy but it can serve as a pilot for upscaling investments at national, regional and European Union (EU) levels.

In addition to the Sunny Schools initiative, OSF-WB is implementing the Green Generation Consortium to engage local stakeholders in climate action, ensuring participation in the just transition and energy democratization.

It builds the capacity of school communities, raises awareness about climate justice, and empowers schools to participate in local decision-making and energy policy, while enhancing their sustainability and advocacy efforts. The project brings together a consortium of organizations, Bosnia and Herzegovina (RESET Foundation), Kosovo (Bonevet), North Macedonia (National Youth Council of Macedonia), Serbia (Belgrade Open School). During the first part of 2024, the Green Generation Consortium finished their work with the 2nd wave of Sunny Schools. Through 21 local campaigns, over 20.000 students, teachers, and parents gained awareness of climate change. 63 workshops in 21 schools engaged 1575 pupils, while 12 capacity-building sessions equipped 100 school staff with skills in project management, fundraising, and advocacy.

The initiative also supported 21 small-scale project applications and the development of fundraising and advocacy plans, ensuring schools become proactive leaders in the green transition.

Green Generation – Schools Engaged for Climate Action 2.0 intends to expand climate education and advocacy in new schools. Led by the National Youth Council of Macedonia, National Youth Council of Macedonia, Roma and Egyptian Youth Movement (Albania), Center for Ecology and Energy (Bosnia and Herzegovina), BONEVET(Kosovo), Belgrade Open School-BOS (Serbia). Community engagement played a significant role in the project with forums held in targeted municipalities to help schools identify and prioritize eco-projects funded by energy savings from solar panel installations.

These forums brought together students, teachers, parents, and local officials to collaboratively design solutions addressing school and community needs. Schools presented their priorities, which were then publicly submitted to municipalities for funding based on the incomes generated by Sunny Schools PV infrastructure. Workshops on climate and solar energy educated primary and secondary students, with training in Shkoder reaching 400 students.

PURPOSE AND SCOPE OF THE IMPACT ASSESSMENT



AIM

To assess externally the impact of the “Sunny Schools” Initiative to the health of project beneficiaries such as pupils, school staff, families and wider community populations.

SPECIFIC OBJECTIVES:

- To assess the health status of the children by means of their school absenteeism in the intervention schools compared to control ones.
- To determine potential direct and indirect health effects of the intervention among pupils including physical health (acute respiratory infection (ARI), fever, asthma, allergies and diarrhea) in the project schools.
- To capture the perceived health contribution of the project through a qualitative approach, engaging key stakeholders (local health care unit, school directors, teachers, health professionals)

METHODOLOGY OF IMPACT ASSESSMENT

The methodology of the impact assessment was based on OECD/DAC for evaluations. (OECD, 2021) At the same time the assessment employed Exploratory Sequential Mixed Methods design, ensuring to bring in a participatory and forward-looking approach of the project (Creswell, J. et al). The evaluation involved techniques for PRIMARY and SECONDARY data collection for quantitative, qualitative and observation data. That gave the possibility of bringing in stage triangulated analysis and conclusion (Berman, E. A. et al). This approach remains important, as the expectation can meet mostly from the quantitative data harmonized with other qualitative one (as supportive arguments).

The assessment measured the impact of the intervention related to:

- **Relevance:** The extent to which the intervention objectives and design responded to beneficiaries' health needs.
- **Effectiveness:** The extent to which the intervention achieved its objectives, considering both intended and unintended health results.
- **Efficiency:** How the economic resources/inputs (funds, expertise, time, etc.) converted into health results.
- **Impact:** The long-term health effects produced by the intervention, directly or indirectly, intended or unintended.
- **Sustainability:** Whether the health benefits of the intervention are likely to continue after donor funding has ceased.

Method of data proceeding

The methods for the impact assessment were based in:

- **Secondary data collection** – review of the existing documents
- **Primary Data Collection** – Observation/site visits of the target population in each project site

Matrix 2: *Summary of intervention indicators taken into consideration during the impact assessment*

Indicator	Time	Mean of verification	Explanation
Total number of student absence days per school per year	Annual	School Registers (School absenteeism)	In both intervention control school.
Prevalence of Acute respiratory infection (ARI), fever, asthma and diarrhea, allergies	Annual	Primary Health Care data	Only in intervention schools.
Qualitative information		Key Informative interviews	Only in intervention schools with: • medical staff, school Directors,
Qualitative information		Focus groups with project beneficiaries	• 1 focus group with teachers per each intervention school • 1 focus group with teachers per each control school.

In collaboration with local education authorities, we collected systematic data on school absenteeism of the children in intervention and control schools.

On the other hand, we collected data from the Health Care Services Operator, based on family doctor registers on the acute respiratory infection (ARI), fever, asthmas and diarrhea, allergies for children aged 5–10 and 11–15 for the period 2018-2019, 2022-2025.

School health professionals (doctor/nurses) that work for the Local health care units were interviewed in all the intervention regions together with the family doctors of the children in the intervention schools.

In Annex are provided the primary instruments for data collection.

Sampling method

The sampling techniques were implemented only for the beneficiaries of the project. The project staff, medical staff and local coordinators were interviewed by all of them. As the literature suggests, there was considered an upper limit of 12 participants in the focus groups and 30 participants in the key informant interviews (Boddy, C.R. et al).

There were organized four focus groups with school representatives in each region. We interviewed pupils as the main beneficiaries of the interventions and the representatives of the Local Health care directories, as the family doctors covering the intervention school's area.

Overall, there were contacted the eight health care centers.

Data analysis

The exploration of the findings was done through the qualitative data which were analyzed in the first phase. Then during the second phase to test or generalize the initial findings were analyzed the quantitative data (Berman, E. A. et al). All data were transcribed and analyzed with verbatim. Analysis was based on Conventional Content Analysis, "coding categories are derived directly from the text data" (Murthy et al). During a final phase, the data from the two separate strands of data were integrated and linked (Creswell J et al).

The quantitative data analysis employed Difference in Difference analysis to analyze the absenteeism rate. Difference in Difference (DID) analysis is a quasi-experimental method that relies on the panel structure of the data (usually two periods: based line and follow up - after the intervention 'here installation of photovoltaic system). This method controls unobservable and time invariant characteristics and observable characteristics.

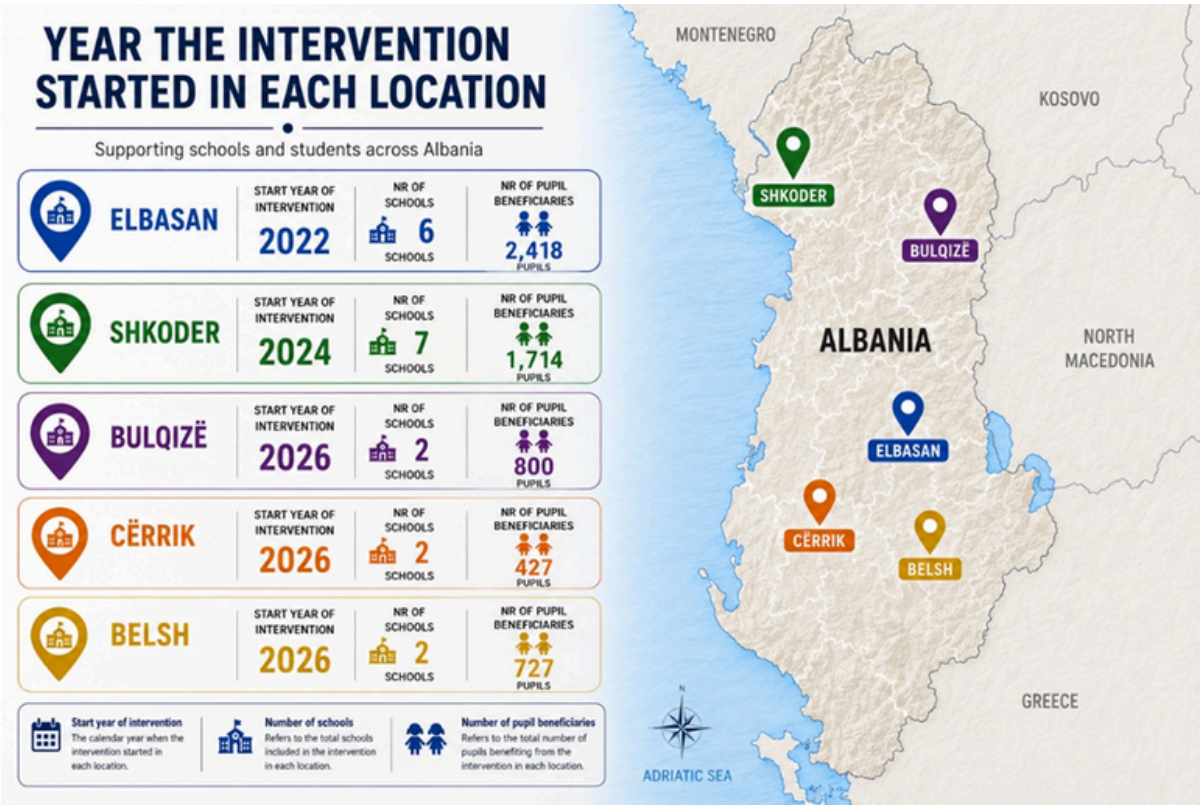
It measures the variable difference among the groups at baseline, an intervention time is set up, both groups are followed and the difference is measured again at the end of the follow up (Villa et al). Difference in difference analysis is widely used to assess the impact of health policies comparing −treated and −control entities (Grabich SC et al). The Treated schools (the one's that installed the panels) were matched with control countries based similar characteristics as being in urban/rural areas, number of pupils and general socio-economic status of the area where the school is located to fulfill the DID assumptions (Angrist JD et al). Control school were schools located in the same region, but they did not start the "Sunny" School intervention. The matrix below informs on the matching schools.

Matrix 3: *The intervention schools matched to the control schools*

No	Intervention schools	Control schools	No	Intervention schools	Control schools
Elbasan			**Shkodër**		
1.	Shkolla "Xhuvani"	Shkolla "Ptoleme Misini"	1.	"Jordan Misja"	28 Nëntori
2.	Shkolla "Abdyl Paralloi"	Shkolla "Jeronim De Rada"	2.	"Oso Kuka"	"Kolë Idromeno"
3.	Shkolla "Sulejman Franci" Mengel	Shkolla 9-Vjeçare Milizë	3.	"Edith Durham"	Isa Jakupi
4.	Shkolla e mesme pedagogjike "Luigj Gurakuqi"	Gjimnazi gjuhesor Mhamed e Ali Cungu	4.	"Nikollë Zagorjani"	Gjergj Vat Martini
5.	Shkolla "Jorgji Dilo"	Shkolla "Naim Frashëri"	5.	"Tring Smajli" Grude e re	Shkolla 9-Vjeçare Dedë Gjo Luli, Rrethinat
6.	Shkolla "Europa" Katund i Ri	Shkolla "Alush Lleshanaku" Shkolla Bradashesh	6.	"Dëshmorët e Rrencit"	Zef Jubani
			7.	"Dëshmorët e Prishtinës	Branko Kadia
Çërrik			**Belsh**		
No	Intervention schools	Control schools	No	Intervention schools	Control schools
1.	"7 marsi"	Xhemali Plaka	1.	"Halit Uruci"	-
2.	"Osman Gjini"	Vali Belshi, Shtërmen	2.	"Seferan"	-
Bulqizë, Dibër					
1.	"Shefqet Tanci"	Selim Aliu, Dibër	2.	"Xhevodet Doda"	Maqellarë

The infographic below informs us of the year in which each school started the intervention. The data provided are based on the declaration of the school principals made during the interviews.

Infographic 1: *The year the intervention started in each project location, no of beneficiary in the current year of implemention and no of schools*



The school principals in Bulqizë, Cërrik and Belsh declared that the photovoltaic systems in their school had been put in place during 2026 but were not installed yet. For this reason, we excluded these regions from further statistical analysis as there could not be measured a health effect of the intervention without connection of the panels. A Difference in Differences regression was performed to estimate the effect of Photovoltaic panels instalment on the schools absenteeism during the pre- and post- instalment periods of time among intervention and control countries.

$$Y_{st}=\beta(Treated_s \times Post_t)+\alpha_s+\gamma t+\epsilon_{st}$$

Where:

- Y_{st} = Health outcome for school s at time t (absenteeism rate)
- $Treated_s$= 1 for intervention schools, 0 otherwise
- $Post_t$ = 1 after intervention, 0 before
- α_s = School fixed effects (controls for time-invariant school characteristics)
- γt = Time fixed effects (controls for common shocks)
- β= The DiD estimator → causal effect of the intervention
- ϵ_{st} = Error term (clustered at school level)

The Difference-in-Differences (DiD) analysis assessed whether changes in school absenteeism following implementation of the photovoltaic intervention differed from changes observed in matched comparison schools. The dependent variable was the annual school absenteeism rate, calculated as the total number of student absentee days divided by the total number of possible student attendance-days during the school year. For reporting, the rate was expressed as a percentage; consequently, the DiD coefficients are interpreted in percentage points of absenteeism.

Meantime, the prevalence of Acute respiratory infection (ARI), fever, asthmas and diarrhea, allergies, were analyzed based on a longitudinal ecological analysis, conducted using routinely collected health-center data from Shkodër and Elbasan. The year 2019 was used as the baseline reference year prior to implementation of the intervention. Same as above, the data from Health Care Services operator for Bulqizë, Cërrik and Belsh were not considered for this regression as the impact cannot be measured for an intervention that has not given its effects yet (the intervention was ongoing in 2026)

Table 1: *The post-intervention period was defined as:*

Region	Intervention year	Post-intervention period
Elbasan	2022	2022–2025
Shkodër	2024	2024–2025

The statistical analysis was performed in two levels:

1. Crude baseline-versus-post comparison

For each disease, Crude rate ratios (RRs) were calculated.

$$RR = \frac{Number\ of\ Reported\ cases}{Number\ of\ Registered\ children} x\ 1000$$

Crude rate ratios (RRs), with 95% confidence intervals, were then calculated by comparing pooled post-intervention incidence rates with baseline 2019 rates.

2. Adjusted regression analysis

Adjusted rate ratios (IRRs) were estimated using Poisson regression models. The unit of analysis was the health-centre–year observation, with the annual number of reported cases of each disease used as the outcome variable.

The corresponding number of registered children in each health centre and year represented the population at risk and was used as the denominator. Because the size of the registered child population differed between health centres and over time, the natural logarithm of the registered population was incorporated into the Poisson regression as an **offset term**. This allowed the model to estimate changes in disease incidence rates rather than changes in absolute numbers of cases.

The models were additionally **adjusted for region (Elbasan/Shkodër)** to account for systematic geographical differences in morbidity and **for calendar year** to account for temporal variation in disease occurrence that could be independent of the intervention. The analytical model therefore accounted for both differences in population size and differences in intervention timing between Elbasan and Shkodër. The analytical model accounted for differences in intervention exposure periods between Elbasan and Shkodër.

The general regression framework was:

$$\log(Y_{it}) = \beta 0 + \beta_1 Post_{it} + \gamma_i + \delta t + \log(Population_{it}) + \varepsilon_{it}$$

Where:

- Y_{it} = represents the number of disease cases,
- $Post_{it}$ = indicates post-intervention exposure,
- γ_i = represents regional effects,
- ε_{it} = represents year effects,
- population size was included as an offset term.
- Statistical significance was considered at $p < 0.05$.

Rates were calculated as reported cases per 1,000 registered children. This report used crude post/pre rate ratios with 95% confidence intervals.

Table 2: *Population offset per each health care centre based on location and calendric year*

Region	Number of children 5–10 years old registered in the center					Number of children 10–15 years old registered in the center				
Year	2019	2022	2023	2024	2025	2019	2022	2023	2024	2025
Elbasan No. 1	733	758	734	448	461	926	971	980	984	970
Elbasan No. 2	376	390	425	449	461	401	430	498	535	548
Elbasan No. 4	1293	1254	1233	1146	1070	1014	912	955	1039	665
Shkodër No. 1	1150	1171	1159	1103	1070	1214	1204	1182	1145	1102
Shkodër No. 2	1288	1242	969	941	665	1321	1381	1460	1486	965
Shkodër No. 3	1159	1108	1175	1154	1145	1164	1092	1186	1179	1120
Velipojë	77	71	73	72	69	68	69	71	70	68

Theoretical background of measuring the health impact of an intervention

According to the World Health Organization (WHO), health outcomes may manifest over short-, medium-, or long-term periods depending on whether the intervention affects immediate determinants of health, behavioral risk factors, or chronic disease pathways. Environmental and infrastructure interventions, such as improvements in school environments, renewable energy implementation, or air quality measures, often require prolonged exposure before statistically significant health effects can be observed. (WHO 2021).

In the context of school-based infrastructure interventions, including the installation of photovoltaic systems, the intervention must first become fully operational before any exposure-related effects can reasonably occur. Only after the systems are connected and actively functioning can changes in indoor environmental quality, thermal comfort, energy reliability, or related educational and psychosocial conditions begin to influence pupils' health and wellbeing. Consequently, measuring health outcomes before the intervention is operational may lead to biased or misleading conclusions because the population has not yet been exposed to the intervention conditions.

Methodological literature on impact evaluation further emphasizes the importance of allowing an adequate "latency period" between intervention implementation and outcome assessment. OECD defines impact as the long-term effects produced by a development intervention, whether direct or indirect, intended or unintended. Therefore, impact evaluations generally require sufficient follow-up periods to distinguish true intervention effects from natural variability or short-term fluctuations (OECD, 2021).

Similarly, studies evaluating environmental and school health interventions commonly recommend follow-up periods ranging from several months to multiple years depending on the outcomes examined. Short-term indicators such as absenteeism, thermal comfort, respiratory symptoms, or concentration may begin to change within months after implementation, whereas broader outcomes related to chronic disease, educational attainment, or psychosocial wellbeing often require longer observation periods.

Exclusion criteria

We took into consideration the fact that data collection for the period 2020-2021 may be influenced by Covid 19 pandemic and health status of the population may be confounded. As explained above, the school principals in focus groups in Bulqizë, Cërrik, and Belsh reported that the photovoltaic systems at their schools were introduced in 2026 but had not yet been installed or connected at the time of the assessment. Consequently, these regions were excluded from both statistical regression models, as it was not yet possible to evaluate any potential health effects of the intervention prior to the systems becoming operational.

Three school namely "Luigj Gurakuqi" School, "Oso Kuka" school and "Deshmoret e Rencit" have been excluded from the difference in difference analysis as the data from their control school have not been provided by the Regional Education Authority.

Limitations

1. Even though we performed a longitudinal ecological analysis of routinely **collected health-center data from Shkodër and Elbasan two main limitations can be recognized:**

- The Health Care Data included children 5-15 years old living in the intervention school area, but not necessarily these children frequented our interventions schools. There are cases that the Albanian families may chose other school for their children rather than the public school that is close to their residence.

- It was not possible to compare the morbidity data with other health care centers that would serve as control ones.

- The analysis of the changes in disease rates over time, does not allow quantification of multiple factors that may have influenced it. The intervention may be only one of the factors that have brought about the improved wellbeing.

Hands, the morbidity data findings cannot be attributed to the intervention per se rather than it informs on the morbidity trends for the period before and after intervention in the general context of school children's communities.

2. The causal interpretation of the DiD findings is limited by uncertainty regarding the parallel-trends assumption. Although examination of the available pre-intervention data provided reasonable support for parallel trends for some matched school pairs, this assumption could not be demonstrated consistently across all comparisons. Consequently, statistical significance of the DiD coefficients can not, by itself, be interpreted as evidence of a causal intervention effect. Rather, the estimates ca be interpreted as **indicating differential changes in absenteeism between intervention and comparison schools that are temporally associated with the intervention.**

Ethics and confidentiality

As external experts, our commitment was to ensure confidentiality of data. Children and adults were protected from both deliberate and accidental harm and abuse.

Result

Overview of qualitative findings as per OECD criteria's

Relevance

The qualitative evidence suggests that the intervention was highly relevant to the needs of schools, particularly in relation to infrastructure, hygiene and learning conditions.

Across multiple schools, teachers emphasized that the introduction of solar panels addressed longstanding deficiencies in basic services, including access to warm water, heating, and improved sanitary conditions. In several cases, respondents described the intervention as one of the most beneficial improvements implemented in their schools, noting that it contributed not only to staff wellbeing but also to students' daily experience. The need for such improvements was especially evident in schools facing structural challenges, such as aging infrastructure and limited access to reliable energy. For example, in some settings, the geographical position of the school and exposure to sunlight made the intervention particularly appropriate and justified.

However, the relevance of the intervention was not uniform across all schools. In some cases, respondents indicated that while solar panels were beneficial, other pressing infrastructure needs—such as outdated electrical systems or insufficient heating solutions —remained unaddressed. This suggests that although the intervention aligned well with key needs, it did not fully respond to the broader infrastructural challenges faced by schools.

In Elbasan, teachers praised the panels as "one of the best things done" – warm water and improved sanitation motivated both students and staff and classrooms were no longer as cold. As one school director mentioned:

> *"Students were eager to come to school, they can wash with warm water"*
>
> **"Europa" School Principal**

In Shkodër, it was noted that "Edith Durham" school position facilitated the well function of photovoltaic rooftops given its sunny location, whereas teacher from "Oso Kuka" school mentioned:

> *"Who would not have needed the solar panels"*

In Dibër region, the panels had just been installed, and the focus of the discussion was on basic deficits. Schools like Bulqizë and Maqellarë (control school) had no hot water or modern boilers at all. For example, one teacher from Bulqizë reported:

> *"There is a problem with hot water, we have no hot water at all. Boilers need to be installed. Our children are that poor that sometimes we provide showers to them in school".*
>
> **"Xhevdet Doda" school Principal**

As well in Cërrik and Belsh the solar panels were only put in place but not installed yet. Respondents emphasized that true need extended beyond solar panels – the schools desperately needed boilers, double-glazing and proper wiring.

In sum, the project addressed a clear demand for better heating and hygiene, but respondents universally stressed that panels should accompany broader infrastructure upgrades.

Effectiveness

The intervention's core objective was promoting energy democracy by transforming public schools into energy-neutral entities – through the development of photovoltaic rooftops. The interviewees reported high effectiveness regarding promotion of energy democracy. On the other side, they noted partial effectiveness regarding transformation of public schools into energy-neutral entities.

In several cases, teachers reported improvements in classroom conditions, including better temperature regulation, increased comfort and improved air quality. These changes were associated with enhanced student concentration and a more positive learning environment.

In addition, improved hygiene conditions, such as access to warm water and upgraded sanitation facilities, were perceived as important benefits. Teachers and school staff noted that students were more comfortable and better able to maintain hygiene, which contributed to both physical and psychological wellbeing.

In Elbasan, a teacher form "Jorgji Dilo" school observed:

> *"Children are calmer, do not get sick as often, they do not stay at school with cold hands, they are more comfortable"*
>
> **"Jorgji Dilo" School Teacher**

In the Shkodër region, the "Edit'h Durham" school replaced gas heating with solar-powered heating and therefore they noted:

> *"Classrooms are warmer, more comfortable and students' concentration is improved"*
>
> **"Edit'h Duham" School Principal**

However, the effectiveness of the intervention was limited in schools where supporting infrastructure was inadequate. For instance, in some cases the existing electrical systems were too weak to support the new energy capacity, or heating systems remained unchanged. As a result, the expected improvements were either partial or not immediately observable.

Two students of *"Ptoleme Xhuvani"* school (14 years old) said that the difference in students' wellbeing would be evident if the photovoltaic rooftops would be accompanied with air conditioner instalments.

As well as, "*Oso Kuka*" school in Shkoder reports that they continue to have an oil heating and therefore they did face any clear change:

> *"There is no change in the health status of pupils"*
>
> **"Oso Kuka" School Principal**

Interviewed doctors expect long-term health effects but note that improvements will take time. Medical staff further emphasized that health-related benefits, particularly reductions in illness, are likely to emerge over a longer period and may not yet be fully visible. One doctor covering area of "Abdyl Paralloi" and "Luigj Gurakuqi" schools' area said:

> *"Of course, these interventions will have a health effect, but its benefits are not immediately visible and cannot be measure today. Now the school electricity costs are decreasing and in long run, together with other infrastructure interventions, and improvement of heating systems in schools, we hope to see the change in children's wellbeing"*
>
> **Pediatrician at the "Health Care Center nr.4", Elbasan**

In conclusion, the intervention can be considered effective in improving school environments, but its outcomes were uneven and highly dependent on contextual factors. Overall, beneficiaries experience some positive change in comfort/hygiene, but only when the solar system is fully operational and accompanied by other upgrades can we measure the real influence in beneficiaries' health. **(Confidence: Medium–High.)**

Efficiency

The efficiency of the intervention appears to be mixed. On one hand, respondents acknowledged that the use of solar energy contributes to reduced energy costs and offers the potential for long-term financial savings. On the other hand, several participants highlighted that these benefits were not always fully realized at the school level.

Efficiency considerations revolved around how resources (electricity or cost savings) were used post-installation. Interviews indicated that the original investment in panels was justifiable given the energy access it provided, but efficiency gains could be improved.
For example, teachers in Elbasan were aware that excess energy was being sold back to the grid and argued that the revenue "should be managed based on the schools' needs."
In fact, the "Luigj Gurakuqi" school reinvested panel profits into renovating two ground-floor bathrooms – a tangible efficient reuse of funds.

However, in most cases such reinvestment was not systematic. Some sites had no mechanisms to channel savings into school budgets, leading to inefficiencies. Several respondents pointed out missed opportunities: they suggested installing water and air filters, or improving sanitation, using the saved energy funds. Participants noted that financial benefits, such as savings or surplus energy, were not always directly reinvested in schools. This limited the perceived value of the intervention and reduced its overall efficiency from the perspective of beneficiaries.

On the other side, a key issue identified was the lack of integration between the solar panel system and other essential infrastructure components. For example, without adequate heating, ventilation, or upgraded electrical systems, the energy generated could not be fully utilized. This was the case of the school in Mengel, Elbasan where they continue to heat with wooden stuffs and the school in Velipoje, Shkoder, where the traditional combustion fuels are still in use.

Medical staff and teachers both stressed that investments in solar energy should be accompanied by complementary improvements in infrastructure to maximize effectiveness. Medical staff also recommended better targeting of resources: any financial "gain on the electricity budget" should be directed towards school hygiene infrastructure.
In Shkodër, proposals included selling surplus energy to the grid at a lower price or addressing grid losses through municipal action.

These comments reflect a desire for greater cost-effectiveness – ensuring that the project's benefits are fully captured by the schools. In short, while the panel installations created potential for efficiency (lower bills, energy sales), realizing those gains required deliberate planning.

In conclusion, there is a clear need for advocacy to provide a local law enforcement on how the schools as an energy production entity can sell the energy to the grid and manage their benefits.

Impact

The intervention impact on health and wellbeing were positively perceived but not generalized. Across sites, stakeholders noted improved conditions that are likely to correlate with better health: warmer classrooms, availability of hot water for handwashing, and increased morale. Medical staff highlighted the potential for longer-term health impacts, including reductions in respiratory infections and improved wellbeing. At the same time, the impact was not uniformly experienced across all schools. In some cases, respondents reported minimal or no noticeable changes, particularly where complementary systems such as heating or ventilation were lacking. This suggests that the overall impact of the intervention is still evolving and depends on the broader context in which it is implemented.

Interviewees point to potential long-term impacts, especially on student well-being and health. Teachers suggested that if scale-up occurs, concrete contracts between the schools and the local government need to be put in place. For instance, Elbasan teachers recommended:

> *"Each school should be able to manage the gained funds from energy saving and use the based on each school's needs. These decisions should not be taken without involvement of school's input"*
>
> **"Ptoleme Xhuvani" school teacher**

On the other hand, the School Principal of "Dëshmoret e Prishtinës" School mentioned:

> *"Based on our observations, we cannot say with certainty that the reduction in student absenteeism is directly attributable to the installation of the solar panels. However, since their installation in 2024, we have observed improvements in the school environment, particularly in terms of thermal comfort and indoor air quality. These improved conditions may have positively influenced students' wellbeing and the teaching and learning process. Regarding health outcomes, we do not have medical data that would allow us to confirm a direct health effect. Nevertheless, we have observed no negative effects; on the contrary, the school environment has become more comfortable and conducive to learning"*

Medical staff identify reduced respiratory infections as a likely impact. One doctor said:

> *"The main health impact is a reduction in viral/bacterial respiratory infections. Children who face ARI from "Luigj Gurakuqi" school are sporadic. There are no patients with asthma in this school. Patients do not refer to the fact that they had cold at school. You do not hear often this phase anymore."*
>
> **Family physician at "Health Care Center nr. 1", Elbasan**

Furthermore, there is an eventual impact pathway: solar-heated water and improved heating are likely to reduce factors that facilitate infections (e.g., damp or cold environments). However, respondents also cautioned that these impacts hinge on using the energy output fully. They expected even larger health benefits if paired with air filters, heating systems, or ventilation.

In summary, while stakeholders' sense real health gains (fewer colds, better hygiene) from the photovoltaic panels**. (Confidence: Medium.)**

Sustainability

The sustainability of the intervention appears promising but remains conditional on several factors. A key strength is that solar panels represent a long-term asset that continues to provide benefits beyond the duration of the project. The long-term benefits depend on maintenance, infrastructure and local policies.

Respondents noted that improvements in energy access, hygiene, and infrastructure are likely to persist over time.

In some cases, there was evidence that energy savings or surplus energy had been reinvested in school improvements, such as upgrading sanitation facilities. This suggests the potential for a sustainable cycle of reinvestment and improvement.

One school's community ("Luigj Gurakuqi") has already built 2 new bathrooms using panel revenues, and doctors expect the panels to provide better conditions indefinitely as less children faced Asthma, Diarrea and ARI.

However, significant challenges remain. Participants emphasized the need for clearer agreements with local authorities regarding the management and use of energy savings. In addition, technical issues, such as outdated electrical systems, may undermine the long-term functionality of the intervention.

In Shkoder, only one school can fully use the panels as their heating system was replaced with functional electric heating, While Oso Kuka school suffers grid losses that might come due to dual connection.

All agree that unless municipalities and school administrations clarify agreements and invest in complementary infrastructure (insulation, hot-water boilers, ventilation), the project's promise may fade.

In Dibër, teachers reported that electrical wiring and outlets are outdated or non-functional. One of the schools in Cërrik faces the same situation:

> *"Electrical cables can't hold resistance... the electric system can't support the load"*
>
> **School "Osman Gjini" School Principal, Mollas, Cërrik**

There were also suggestions that schools should have greater control over how the benefits of the intervention are used, including the possibility of managing or redistributing surplus energy within the community.

Overall, the stakeholders were optimistic about the intervention's sustainability, provided maintenance and complementary investments occur. The solar panels themselves were seen as a durable asset ("the panels will be there forever," one interviewee noted), offering free energy into the foreseeable future.

Teachers mentioned that the improved lighting and warmth would persist, helping schools "never become infection hotspots". The fact that some schools have already ploughed panel revenue back into facilities (bathrooms, sheds) is a promising sign for financial sustainability. Community awareness around energy use also increased, which could support ongoing care of the systems.

However, all respondents emphasized the need for institutional support to sustain gains. As the health workers insisted on continual advocacy to fund improvements in other schools.

The table below scores the intervention on a simple 1–5 scale, where 1 is very weak, 3 is mixed, and 5 is very strong. These are evaluator judgments anchored in the uploaded evidence and interpreted through the OECD framework.

Table 3: *The intervention scores on a simple 1–5 scale interpreted through the OECD framework*

Criterion	Score	Evidence-based judgment
Relevance	5	**Very high.** Baseline needs were clear: cold classrooms, weak or absent hot water, deteriorated sanitation, poor electrical systems, and continued reliance on wood or other polluting heating in some schools.
Coherence	3	**Mixed.** The intervention aligns externally with school WASH, clean energy, and indoor-air health logic, but internal coherence was often weak because electrical, heating, ventilation, and governance systems were not upgraded at the same pace.
Effectiveness	2	**Limited as a direct health intervention.** Respondents perceived better comfort, concentration, hygiene, and in some cases fewer illnesses, but the morbidity data do not show a robust overall reduction.
Efficiency	3	**Mixed-to-moderate.** There were reports of energy savings and even reinvestment into school bathrooms, but underused generation, incomplete connections, and weak school electrical systems reduced realized efficiency.
Impact	2	**Weakly evidenced** on attributable morbidity impact. Environmental and enabling effects are visible; direct disease reduction remains uncertain and site dependent.
Sustainability	3	**Moderate.** The physical asset can last, and some benefits were reportedly reinvested, but sustainability depends on maintenance, municipal agreements, grid arrangements, and complementary infrastructure upgrades.

Results of the short-term impact of the intervention at children's health

General overview of morbidity data across the health care centers

Overall, ARI remained the most prevalent condition throughout the study period, while asthma and fever showed relatively stable patterns. In contrast, allergies demonstrated a gradual increase over time.

Diarrhea cases showed moderate variability across the study period. Cases increased gradually between 2019 and 2022, decreased slightly in 2023, and then rose substantially in 2024 before experiencing a small decline in 2025. The fluctuations may reflect changes in environmental conditions, hygiene practices, seasonal factors or healthcare reporting.

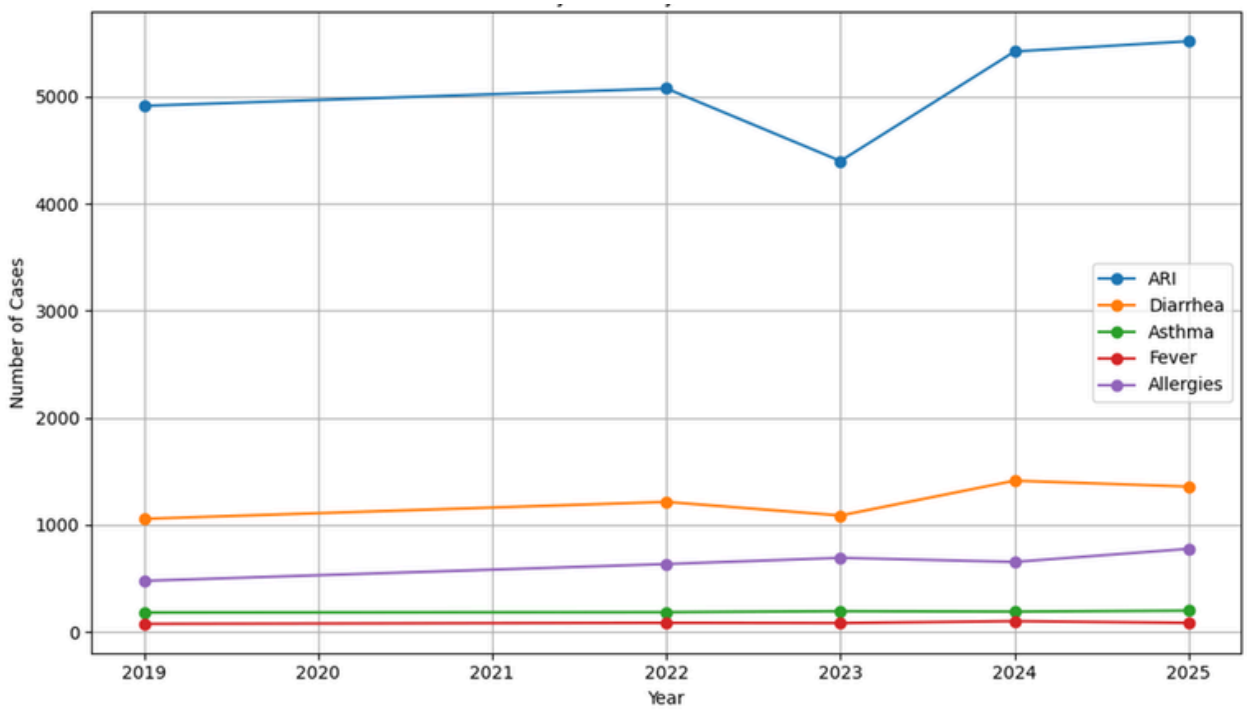
Asthma cases remained relatively stable throughout the years, varying only slightly between approximately 170 and 200 cases. This stability suggests that the prevalence and reporting of asthma did not undergo major epidemiological changes during the study period.

Similarly, **fever cases** demonstrated minimal variation over time, remaining generally between 70 and 100 cases. A small increase was observed around 2024, but overall, the trend remained stable, indicating a relatively constant burden of febrile illnesses.

Allergy cases showed the clearest upward trend among the conditions analyzed. The number of reported allergy cases increased steadily from approximately 450 cases in 2019 to nearly 800 cases in 2025. This increase may be associated with environmental changes, greater exposure to allergens, improved diagnosis or increased awareness of allergic conditions.

The graph illustrates morbidity trends for five health conditions—Acute Respiratory Infections (ARI), diarrhea, asthma, fever, and allergies—between 2019 and 2025.

Graph 1: *Morbidity trends by disease and year*



The analysis by health care centres demonstrates important variations in morbidity trends across the different primary health care facilities in Shkodër and Elbasan. Overall, Acute Respiratory Infections (ARI) remained the most reported condition in all centres, while allergies generally showed an increasing trend over time. However, the magnitude and direction of changes differed considerably between health care centres.

In Primary Health Care Centre no.1 in Shkodër, there was a marked increase across almost all disease categories between 2019 and 2025. ARI cases more than doubled during the study period, while diarrhoea and allergy cases showed particularly strong increases. Allergy cases increased steadily from 102 cases in 2019 to 265 cases in 2025. Asthma and unexplained fever also demonstrated upward trends, although at lower levels. This Primary Health Care Nr.1 in Shkodër showed one of the clearest overall increases in morbidity burden over time.

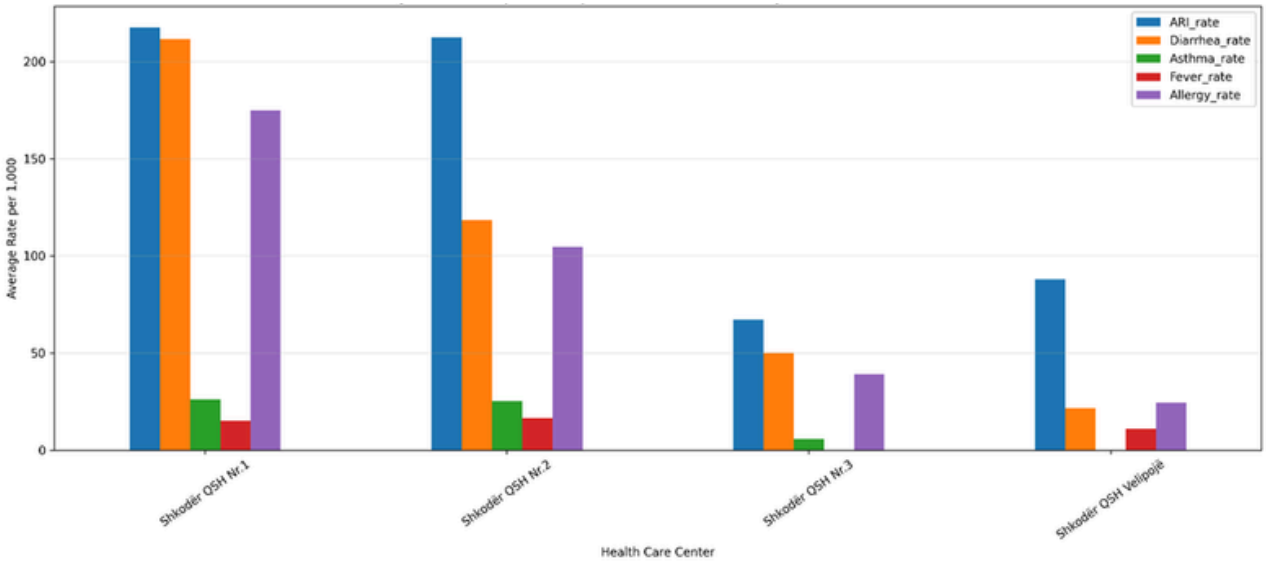
In Primary Health Care Centre no.2 in Shkodër, ARI cases also increased substantially, although the rise in other diseases was more moderate. Diarrhea and allergy cases remained relatively stable, while asthma cases showed little variation over the years. Fever cases fluctuated only slightly. Compared with QSH Nr.1, this centre demonstrated a more stable morbidity profile, with the main increase concentrated in respiratory infections.

In Primary Health Care Centre no.3 in Shkodër, morbidity trends appeared relatively stable throughout the study period. ARI cases remained almost unchanged between baseline and 2025, while diarrhea cases slightly decreased over time. Asthma and allergy cases showed small increases, but no major epidemiological shifts were evident. Overall, this centre demonstrated the most stable health indicators among the Shkodër facilities

In Primary Health Care Centre Velipojë, trends differed from the other centers. ARI cases increased modestly, while diarrhea and allergy cases declined over time.

Fever cases remained stable, and asthma cases were either absent or minimally reported. This suggests a relatively stable or improving morbidity situation compared with the other centres.

Graph 2: *Avarage morbidity rates per 1,000 children by Health Care center in Shkoder for the period 2019-2025*



In **QSH Nr.1 in Elbasan**, ARI cases increased substantially from 811 cases in 2022 to more than 1,100 cases in 2025, despite a slight reduction after the 2024 peak.

Diarrhoea cases also increased gradually, while allergy cases nearly doubled during the observed period. Fever cases fluctuated at low levels. The findings suggest a progressive increase in respiratory and allergy-related morbidity within this centre.

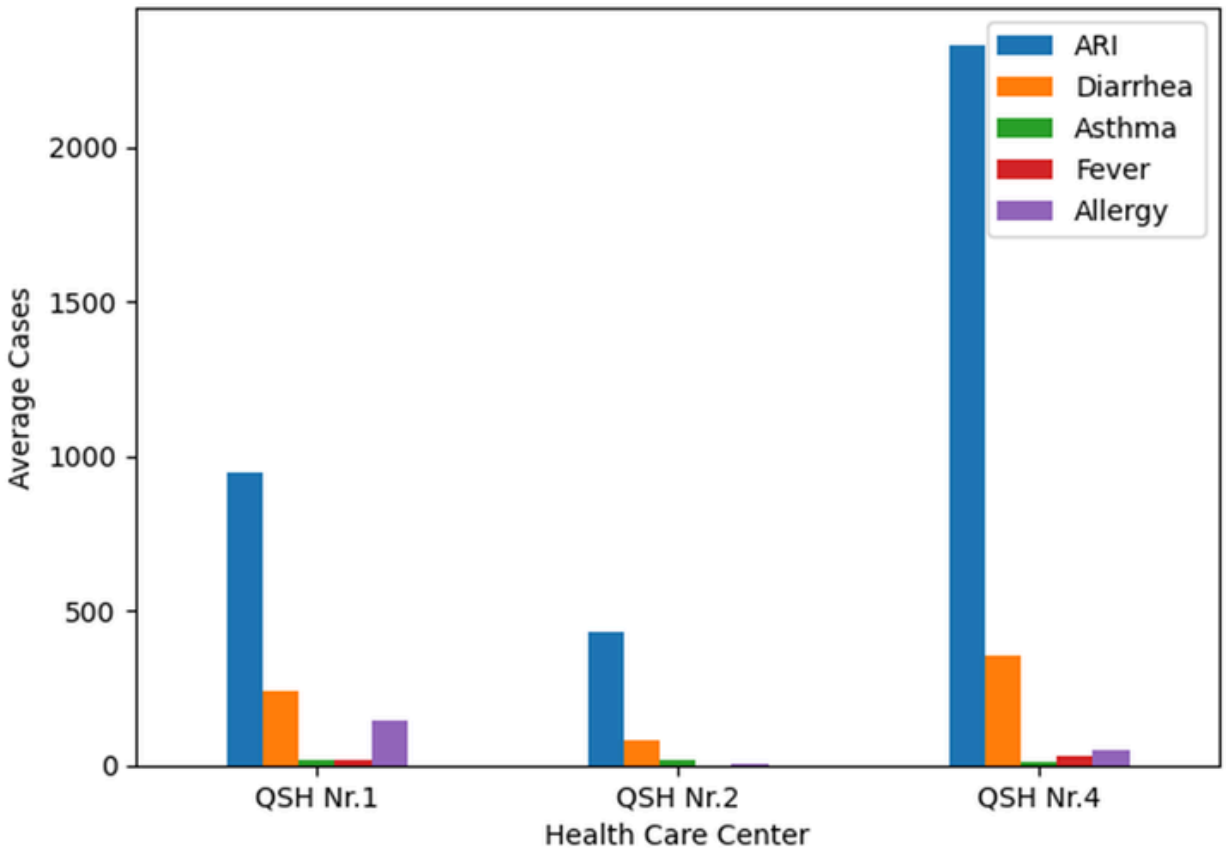
In **QSH Nr.2 in Elbasan**, ARI and diarrhoea cases increased steadily across the years, although the absolute numbers remained lower compared with other centres.

Allergy cases fluctuated slightly but showed an overall upward tendency by 2025. Fever cases remained absent or extremely low throughout the period, indicating a relatively limited burden of unexplained febrile illness.

In **QSH Nr.4 in Elbasan,** ARI represented an exceptionally high burden compared with all other centers. Although ARI cases declined temporarily in 2023, they remained consistently elevated overall. Diarrhea cases showed a gradual decrease over time, while allergy cases fluctuated without a clear increasing trend. Fever cases remained relatively stable.

This centre appears to carry the largest respiratory disease burden among all analysed facilities.

Graph 3: *Avarage morbidity burden by Health Care center in Elbasan for the period 2019-2025*



Overall, the centre-level analysis demonstrates considerable heterogeneity in morbidity patterns across health care facilities. While respiratory infections increased in nearly all centres, the trends for diarrhoea, fever, asthma, and allergies varied substantially depending on the local context. These differences may reflect variations in population size, environmental exposures, healthcare utilization, reporting practices, or local socioeconomic and infrastructural conditions.

Baseline-versus-post comparison and adjusted models

This section of results compares the morbidity rates before and after the intervention, together with the crude relative risk (RR) and adjusted incidence rate ratio (IRR) for each disease category. Overall, the findings suggest statistically significant increases in ARI, unexplained fever, and allergy cases in the post-intervention period, while no significant changes were observed for diarrhea and asthma.

For Acute Respiratory Infections (ARI), the morbidity rate increased from 329.5 cases in 2019 to a pooled post-intervention rate of 349.8 cases. The crude RR was 1.56, indicating an increase in risk. After adjustment, the IRR was 0.83 (95% CI: 0.76–0.90; p <0.001*), suggesting a statistically significant decrease in ARI incidence during the post-intervention period compared with baseline.

Diarrhea rates increased from 70.5 to 86.7 cases, with a crude RR of 1.65. The adjusted IRR of 0.84 (95% CI: 0.75–0.93; p = 0.001) wasstatistically significant.
Asthma morbidity also showed a slight increase from 12.2 to 13.2 cases, with a crude RR of 1.6. Nevertheless, the adjusted IRR was 0.87 (95% CI: 0.62–1.22; p = 0.421), demonstrating no statistically significant difference between the pre- and post-intervention periods.

In summary, the adjusted analyses indicate significant decreases in ARI, Diarrhea, and allergies following the intervention period, whereas Unexpected fever and asthma did not demonstrate statistically significant changes.

Table 4: *The adjusted analyses results per morbidity*

Disease	2019 rate	Post pooled rate*	Crude RR	Adjusted IRR (95% CI)	P
ARI	336.8	526.4	1.56	0.83 (0.76–0.90)	<0.001*
Diarrhea	75.8	124.8	1.65	0.84 (0.75–0.93)	0.001*
Asthma	7.5	12.0	1.60	0.87 (0.62–1.22)	0.421
Unexplained fever	5.7	8.3	1.47	1.02 (0.68–1.54)	0.915
Allergy	34.1	53.9	1.58	0.63 (0.53–0.73)	<0.001*

Crude analyses demonstrated increases in incidence rates across all assessed diseases during the pooled post-intervention period compared with baseline 2019 values. The largest crude increases were observed for diarrhea, asthma, and allergy outcomes.
However, after adjustment for regional and temporal effects, the direction of association changed for several outcomes. Adjusted analyses demonstrated statistically significant reductions in:

- ARI incidence,
- diarrhea incidence,
- allergy incidence.

Specifically:

- ARI incidence was estimated to be 17% lower during the post-intervention period (IRR = 0.83),
- diarrhea incidence was estimated to be 16% lower (IRR = 0.84),
- allergy incidence was estimated to be 37% lower (IRR = 0.63).

Although the timing of the observed changes coincides with the post-intervention periods, the analysis cannot establish that these reductions occurred specifically among pupils attending the beneficiary schools or that they were caused by the solar panel intervention. The quantitative morbidity analysis should therefore be considered as s**upportive contextual evidence of changes in population-level morbidity patterns,** rather than a direct estimate of the intervention's effect on pupils' health.

No statistically significant adjusted associations were identified for asthma or unexplained fever. The discrepancy between crude and adjusted findings suggests that unadjusted increases in disease rates were likely influenced by broader temporal trends, regional variability, or post-pandemic fluctuations in healthcare utilization and disease reporting. After accounting for these confounding factors, the intervention period appeared to be associated with reductions in several key pediatric health outcomes.

Difference in difference analysis results

The Difference-in-Differences analysis demonstrated a general tendency toward reduced absenteeism following implementation of the photovoltaic intervention, although the magnitude and statistical significance varied across schools.

Among schools in Elbasan, the strongest and statistically significant reduction in absenteeism was observed for:

- **Ptoleme Xhuvani compared with Sulë Misiri (DiD coefficient = −15.6**, SE = 3.14; 95% CI: −23.04 to −8.57; **p = 0.001)**

This **indicates evidence of a differential change between groups but does not establish that the intervention caused that change** (SE = 3.14; 95% CI: −23.04 to −8.57; p = 0.001). Before intervention, mean absenteeism was approximately 24.0% at Ptoleme Xhuvani and 3.7% at Sulë Misiri. During the post-intervention period, the corresponding averages were approximately 11.1% and 6.6%. Thus, absenteeism fell substantially in Ptoleme Xhuvani while increasing modestly in the comparison school, producing a large negative DiD estimate.

A moderate reduction was also observed for:

- **Sulejman Ranci/Mengel compared with Mlizë (DiD coefficient = −3.5, p = 0.08)**

Although not statistically significant at the conventional 5% threshold, the result suggests a possible beneficial trend.

The remaining school comparisons demonstrated smaller reductions that were not statistically significant.

Table 5: *Difference-in-Differences estimates for school absenteeism in Elbasan Region*

Intervention school vs comparison school	Intervention year	DiD coefficient	Standard Error (SE)	95% CI	Statistical significance	Unit
Jorgji Dilo × Naim Frashëri	2024	−1.02	1.03	−3.41 to 1.36	p = 0.34	% points
Jeronim de Rada × Abdyl Paralloi	2022	−7.3	12.24	−35.56 to 20.88	p = 0.56	% points
Europa × Alush Lleshanaku	2023	−2.04	2.29	−6.32 to 4.24	p = 0.36	% points
Ptoleme Xhuvani × Sule Misiri	2022	−15.6	3.14	−23.04 to −8.57	p = 0.001	% points
Sulejman Ranci/Mengel × Mllize	2023	−3.5	2.03	−6.81 to 2.54	p = 0.08	% points

In Shkodër, the most notable result was observed for:

- **Dëshmorët e Prishtinës compared with Branko Kadia (DiD coefficient = −14.09, SE = 5.12; 95% CI: −25.88 to −2.28; p = 0.025)**

This indicates a differential change in absenteeism rate between intervention and comparison schools that are temporally associated with the intervention Mean absenteeism in Dëshmorët e Prishtinës was approximately 23.0% during the pre-intervention period and 9.0% in 2024–2025, whereas absenteeism in Branko Kadia remained essentially unchanged at approximately 1.2%. The resulting DiD estimate therefore reflects a substantial differential decline in the intervention school.

Other schools demonstrated either minimal reductions or non-significant changes. This may partly reflect the shorter follow-up period in Shkodër, where interventions were introduced only in 2024, limiting the time available for measurable effects to emerge.

Table 6: *Difference-in-Differences estimates for school absenteeism in Shkodër Region*

Intervention school vs comparison school	Intervention year	DiD coefficient	Standard Error (SE)	95% CI	Statistical significance	Unit
Edith Durham × Isa Jakupi	2024	−1.4	5.96	−15.18 to 12.32	p = 0.81	% points
Nikollë Zagorjani × Gjergj Vat Martini	2024	−3.3	−1.87	−7.71 to 0.90	p = 0.107	% points
Tring Smajli × Hot i Ri	2024	−0.12	11.29	-26.16 to 25.9	p = 0.99	% points
Dëshmorët e Rrencit × Zef Jubani	NA	NA	NA	NA	NA	% points
Dëshmorët e Prishtinës × Branko Kadia	2024	−14.09	5.12	-25.88 to -2.28	p = 0.025*	% points

Discussion of the Results

The findings suggest that improved school infrastructure and renewable energy interventions may contribute indirectly to better child health outcomes, particularly regarding respiratory and environmentally sensitive conditions.

The Difference-in-Differences analysis provides preliminary evidence that the school photovoltaic intervention may have contributed to reductions in school absenteeism in several participating schools.

The strongest differences in absenteeism between intervention and comparison schools were identified in “Ptoleme Xhuvani” school in Elbasan (Did=-15.5, p = 0.001) and “Dëshmorët e Prishtinës” school in Shkodër (Did=-14.9, p = 0.025), informing us about temporally associations with the intervention

Although not all comparisons reached statistical significance, the overall direction of effects was predominantly favourable, suggesting a potential positive influence of improved school infrastructure and energy conditions on student attendance and wellbeing.

While respiratory infections increased in nearly all centres, the trends for diarrhoea, fever, asthma, and allergies varied substantially depending on the local context.

The strongest adjusted effect was observed for allergy-related outcomes (37% lower IRR = 0.63 $p<0.001$), which may reflect improvements in environmental quality within school settings.

Nevertheless, interpretation should be made cautiously. The analysis was ecological in nature and cannot establish direct causality at the individual level.

The findings of this study should also be interpreted in the broader context of environmental health trends in Albania. National data indicate that the age-standardized mortality rate attributable to indoor air pollution in Albania has declined steadily since 1990, decreasing from 215 deaths per 100,000 inhabitants in 1990 to 66 deaths per 100,000 inhabitants in 2021. (Institute of Health Metrics and Evaluation, accessed 2026)

The decline has been largely explained by the reduction in indoor air pollution, likely to reflect improvements in energy use, heating practices, and living conditions. If these country wide data are extrapolated into the project target schools, additional improvements in respiratory health risk for the pupils and teachers are expected in the future. The short-term positive trends observed are expected to only strengthen as indoor air quality of the targeted schools will continue to improve as result of substitution of fossil fuel with green electricity.

Conclusions

The impact assessment provides encouraging evidence regarding the broader benefits of the school solar-energy intervention, but the strength of conclusions differs by outcome. The school-level Difference-in-Differences analysis provides evidence of improved attendance in selected intervention schools, with statistically significant reductions in absenteeism observed for Ptoleme Xhuvani in Elbasan (DiD = −15.6, p = 0.001) and Dëshmorët e Prishtinës in Shkodër (DiD = −14.09, p = 0.025). These results nevertheless varied across schools and should not be generalized to all beneficiary schools.

For morbidity, adjusted health-centre analyses identified lower rates of ARI, diarrhea and allergy during the post-intervention periods. However, because the health-centre data cover wider community catchment populations rather than intervention-school pupils specifically, these reductions cannot be attributed causally to the solar panel intervention. They should instead be regarded as contextual population-level trends that are consistent with, but do not demonstrate, a potential health benefit of the intervention.

Qualitative findings provide additional evidence that the intervention improved aspects of the school environment and help identify plausible mechanisms through which renewable-energy investments could ultimately support pupil wellbeing.

The overall findings therefore suggest that photovoltaic interventions may generate health and educational co-benefits when they enable or are combined with improvements in heating, ventilation, hygiene, hot-water provision and other aspects of school infrastructure.

Further longitudinal analyses with matched comparison schools and longer follow-up periods are recommended to strengthen causal inference. The findings are supported by the medical staff who have observed fewer respiratory complaints and believe health effects will accrue over time if schools further upgrade heating and ventilation.

In addition, we can say with a reasonable certainty that other health positive outcomes are expected in the long-term future among pupils and teachers as results of elimination of burning solid fuels (wood) or oil for heating purposes in school.

The qualitative analysis of focus group discussion and key informative interviews reveals a range of perceptions of the solar panel installations in rural schools from mixed to positive. Teachers and medical staff agree that the intervention addressed a real need for reliable heating, hot water and lighting. Many notes improved classroom warmth, hygiene, and student comfort after installation.

However, these benefits are seen only where supporting infrastructure exists. Chronic infrastructure gaps – cold showers, poor insulation, old wiring and boilers – persist in some sites, limits impact and may have influenced the perceptions of the interviewees.

Participants repeatedly emphasize that solar panels should come with parallel investments (hot-water systems, electrical upgrades, ventilation) to realize full benefits. Efficiency and impact gains thus far are modest: any energy savings or health improvements are largely informal observations.

A few schools have reinvested surplus energy funds into basic upgrades (e.g. new bathrooms), but most still lack clear mechanisms to use savings for school needs. Teachers propose clearer contracts, municipal coordination and sales of energy to the national grid to improve long-term gains.

Even though the data do not provide strong evidence that the solar panel interventions alone reduced morbidity levels regarding acute respiratory infection, diarrhoea, and allergy. Solar panel interventions may contribute indirectly to better health and wellbeing, but any sustained health intervention seem to be linked to broader infrastructural improvements to produce measurable reductions in morbidity.

The qualitative evidence demonstrates also the nuanced implementation experiences. In some schools, especially in Elbasan and parts of Shkodër, teachers and medical staff described better handwashing conditions, warm water, improved comfort, calmer pupils, and better concentration. In other sites, especially in Dibër, Bulqizë, Cërrik and Belsh, participants said the panels were not yet connected, not yet functional or the intervention is underway.

Overall, the intervention represents a promising model for integrating renewable energy solutions into educational settings while contributing to improved school environments, environmental awareness and long-term institutional benefits.

However, the evaluation demonstrates that solar panel installations alone are insufficient unless combined with broader infrastructural improvements and sustained institutional commitment.

Overall, the panels improved conditions if schools address the contextual constraints. Key recommendations are to integrate follow-on upgrades (heating systems, water/air filters, maintenance) and strengthen financial/governance arrangements so that electricity savings are reinvested in schools.

Recommendations

Recommendation 1:

Upgrade complementary infrastructure

Ensure each school pairs solar panels with needed investments: electrical rewiring, modern boilers or heat pumps, hot-water systems, insulation, ventilation/air filters. This will accelerate the clean air transition that has been delayed in some schools.

Recommendation 2:

Ensure reinvestment of savings

Establish transparent mechanisms so that energy savings or revenues (from surplus energy) are allocated to school needs (e.g. hygiene, maintenance, furniture). Teachers suggest managing funds based on each school's needs.



Recommendation 3:

Strengthen stakeholder coordination

Facilitate agreements between schools and municipalities/energy providers to handle grid connections, net metering and community energy sales. For example, consider selling excess energy at subsidized rates to community or public buildings, as locals proposed.



Recommendation 4:

Monitor outcomes.

Monitor simple tracking of attendance and respiratory illness trends in schools over time to gauge impact. Share systematically the health, education, absenteeism data among the schools participating in "Sunny School" initiative.

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Annexes

Instrument for data collection at health care centres

Health Centre 1

Year		2019	2022	2023	2024	2025
Number of cases with acute respiratory infection (ARI)	Total					
	5-10 years old					
	11-15 years old					
Number of cases with Diarrhea	Total					
	5-10 years old					
	11-15 years old					
Number of cases with Asthma	Total					
	5-10 years old					
	11-15 years old					
Number of cases with unexplained Fever	Total					
	5-10 years old					
	11-15 years old					
Number of cases with Allergies	Total					
	5-10 years old					
	11-15 years old					
Number of children 5-10 years old registered in the center	Total					
Number of children 11-15 years old registered in the center	Total					

Each of the health care centres that covered the intervention schools filled in this table.

2. Instrument for data collection of absenteeism in schools

School_____ Year _____

Year	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
Total number of enrolled children in the school									
Total number of student absence days per school per year									
Absenteeism in October									
Absenteeism in November									
Absenteeism in December									
Total number Absenteeism in January									
Absenteeism in February									
Absenteeism in March									
Absenteeism in April									
Absenteeism in May									

3. Questions of the key informative interviews with medical staff

Hello, and thank you for agreeing to speak with me today. Your thoughts on these subjects will be very helpful to us. There are no right or wrong answers to these questions, please answer as you like. We have a recording device to help us remember what you say today and we will take some notes. Your identity will be confidential.

Relevance:

1. How much time do you have offering medical service in this center?

2. In our opinion, does the intervention undertaken in the school fulfill the health needs of all school children and school staff?

Effectiveness:

1. In your opinion, has this intervention, beyond its other effects, had or is it expected to have a future impact on the health of children in the schools where it was implemented?

Efficiency:

1. Do you think it was needed to invest in another direction to achieve better results?

2. To what extent was the project flexible and responsive to changing conditions upon the health and wellbeing of the community?

Impact:

1. Do you identify any long-term health/wellbeing effect of this intervention?

2. If this project would be repeated, what would you change? What would you suggest do in another way?

3. What are the main lessons learnt that you can identify?

Sustainability:

1. Do you identify any health benefit of this intervention that will continue even after the end of the project?

4.Focus group with school teachers

Relevance:

1. Was there a need for solar panels in your school?

2. Were your school's needs taken into account during the implementation of the project

Effectiveness:

1. Did you notice any effect on the physical and mental wellbeing your pupils, after the intervention?

2. In your opinion, has the intervention affected pupils' concentration levels?

3. How would you describe this change? Was it positive or negative?

4. How well was the intervention aligned with the existing infrastructure (e.g., electricity and water systems) of the school

Impact:

1. If this project would be repeated, what would you change? What would you suggest to do in another way?

Sustainability:

1. Can you identify any benefit of the school that you will remember after leaving this project?



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