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PAPER

Uncovering effects of climate-sensitive health risks on historically marginalized youth in Washington State: creating opportunities for maximum involvement

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Abstract

Climate-sensitive hazards, including extreme heat, wildfire smoke, flooding, and rising sea levels, can jeopardize the health of all populations. However, certain population groups are more vulnerable to harm from these hazards. While youth—particularly those from historically marginalized groups and communities—are among those at the highest risk, their abilities may be underutilized in local climate adaptation efforts. This exploratory research aimed to identify opportunities for youth involvement in climate and environmental solutions in their historically marginalized communities. Specifically, this study (1) investigated youth risk perceptions and impacts of various climate-sensitive hazards (e.g. extreme heat, wildfire smoke, flooding, and sea level rise); (2) examined current barriers, resource needs, and opportunities for youth to engage in climate and environmental solution work; and (3) explored current methods and spaces where youth and community leaders can support youth-led climate-related initiatives. Through focus group discussions with youth and in-depth interviews with community leaders who are directly with youth, this study identified opportunities to leverage youth experiences, perceptions, and assets to promote a healthy and resilient community in the face of various compounding climate-related threats. Results showed that while youth recognize the changing climate and associated health impacts, they require more financial resources and support from local decision-makers to maintain their engagement and promote community resilience. Engaging youth in climate action and community resilience involves more than just centering youth voices and perspectives—it requires intentional collaboration, capacity-building, organizing, granting decision-making power, and other strategies to produce inclusive, intersectional, and sustainable solutions.

1. Introduction

Extreme weather and other environmental events have revealed the magnitude and ramifications of increasingly rapid shifts in the climate. Anthropogenic climate change has likewise created unprecedented non-acute (i.e. not resulting from a specific event) shifts in social, economic, and environmental conditions, some with potential cascading impacts on health [1]. The consequences of such climatic change disproportionately impact marginalized communities [2, 3], such as children and youth [4]. Climate and environmental hazards endanger and undermine youth's physical and mental well-being [5]. Youth, especially those who have been systemically marginalized, are more prone than adults to behavioral, psychological, and emotional problems post-disaster [6, 7]. Additionally, experiencing a disaster may result in delayed academic progress, missed social opportunities, and increased exposure to life stressors, such as

family violence, divorce, and alcohol and drug abuse [5, 8]. Furthermore, indirect impacts of climate change, including eco-anxiety or climate grief, can result in youth feelings of dread, anxiety, and despair [9, 10]. These feelings of helplessness and hopelessness go hand in hand, defined as a phenomenon called eco-paralysis: when people care about climate change but feel unable to do anything impactful on an individual level [11, 12]. Providing support, opportunities, and ways to process these emotions and engage in climate justice work may be practical tools to alleviate climate grief and instill a sense of hope [11, 12].

Because youth comprise one of the populations at highest risk, there is a need to reconsider and direct attention to youth roles, perspectives, and abilities in climate adaptation and activities supporting environmental justice (EJ). This exploratory research sought to respond to this need, investigate the experiences of, and identify opportunities for youth ages 13–18 years old to contribute to climate and environmental solutions in their communities. Using focus groups and in-depth interviews, this study aimed to:

- (1) Understand youth risk perceptions regarding the health effects of various climate and environmentally sensitive hazards (e.g. extreme heat and wildfire smoke);
- (2) Examine current barriers, resource needs, and opportunities for young people to engage in climate and environmental solution work, and
- (3) Highlight current youth engagement initiatives related to climate and the environment.

2. Disaster impacts on youth: addressing physical and mental health challenges

Historically, young people have found creative ways to be civically engaged and participate in events that impact them, especially concerning climate change and environmental injustice [13, 14]. Studies have shown how children (under the age of 12) and youth (ages 12–24) differ substantially from adults in how they view climate and environmental-related risks, often expressing severe concern about the frequency and intensity of climate change events [14, 15]. They have also found that youth's knowledge and capabilities around climate justice and resilience hold unique value [8, 16]. Further, children and youth have deep connections with their families and communities [8, 17, 18], which can be leveraged to disseminate new, creative ideas, and they are knowledgeable about the issues arising in their communities [19].

In light of climate change and the current socio-political climate, youth recognize that climate justice is a human rights issue and must, therefore, be addressed with intersectional approaches [20]. Young climate change activists are advocating not only for the safety of future generations but also to address intersectional issues tied to climate justice, such as the impacts of racial discrimination, ableism, sexism, capitalism, and colonialism, and for more holistic and equitable solutions that address collective needs [10, 20]. In a recent study that interviewed queer youth on their perceptions of what it means to be resilient, respondents described resilience as a practice of supporting the wider community, strategizing coping mechanisms to overcome hardships, and celebrating identities while rejecting normative principles that perpetuate marginalization [21]. In addition, in a series of workshops following Hurricane Harvey in Texas, youth expressed concerns about affordable housing, lack of economic and job opportunities, drugs and crime, lack of school funding, and limited spaces for leisure and entertainment in their neighborhoods [22]. Concerns for their communities were accompanied by an interest in participating in community improvement efforts [22].

Despite youth's power to contribute to climate change resilience work, they are often overlooked as resources. For example, youth are frequently labeled as 'passive victims' with limited agency to contribute to disaster response and decision-making [23, 24]. This narrative discourages and subsequently neglects youth autonomy and their inclusion in disaster and climate change scholarship. This lack of opportunity may undermine youth resilience in the face of extreme environmental events. For example, in a survey of 100 school-aged youth conducted across four flood-affected districts in Pakistan, researchers found that school children were less aware and prepared for disasters when they were not educated on disaster preparedness at school and home [25]. A different study, which interviewed 83 children and youth who experienced the 2013 flood in southern Alberta, Canada, found that increasing youth's knowledge and understanding of climate change, in turn, increased their environmental awareness and concern [26].

However, there are several positive examples of the impact young people can have on environmental work in recent years [27]. Amariyana Copeny, or 'Little Miss Flint,' created an initiative to raise \$1 million for water filters to address the water crisis in Flint, Michigan, following the revelation of dangerous lead levels impacting the mental and physical development of Black and Brown youth in her community [28]. This initiative, which has been active for almost four years, responds directly to the lack of governmental assistance in Flint and the persistent reoccurrence of environmental and racial injustices [28]. As a teenager, Isra Hirsi—a co-founder and executive director of the U.S. Youth Climate Strike—organized hundreds of

student-led strikes throughout the U.S [29]. These strikes sought to raise awareness of the climate change crisis and advocate for responsible government intervention. In 2023, 16 young people between the ages of 2 and 16 won a lawsuit against the state of Montana, challenging a provision under the Montana Environmental Policy Act, arguing that the amendment violated a provision of the state constitution that protects the right to a clean and healthful environment [30].

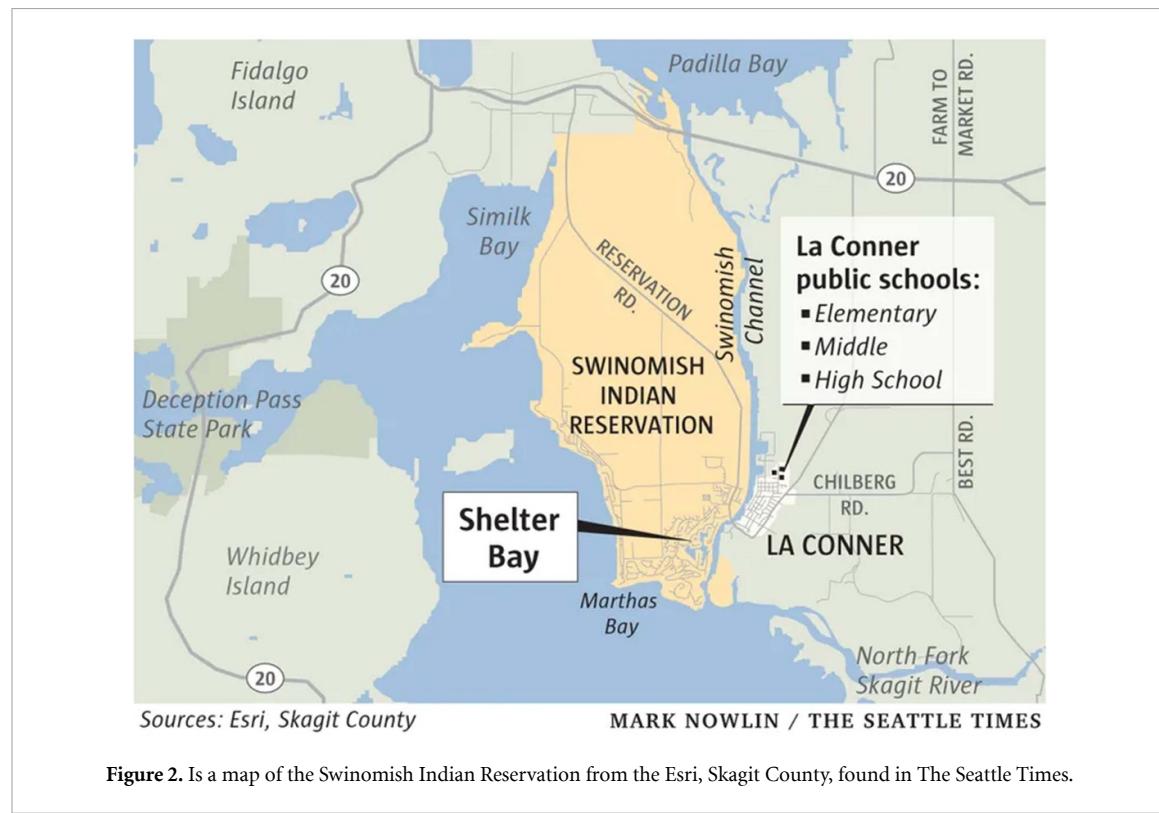
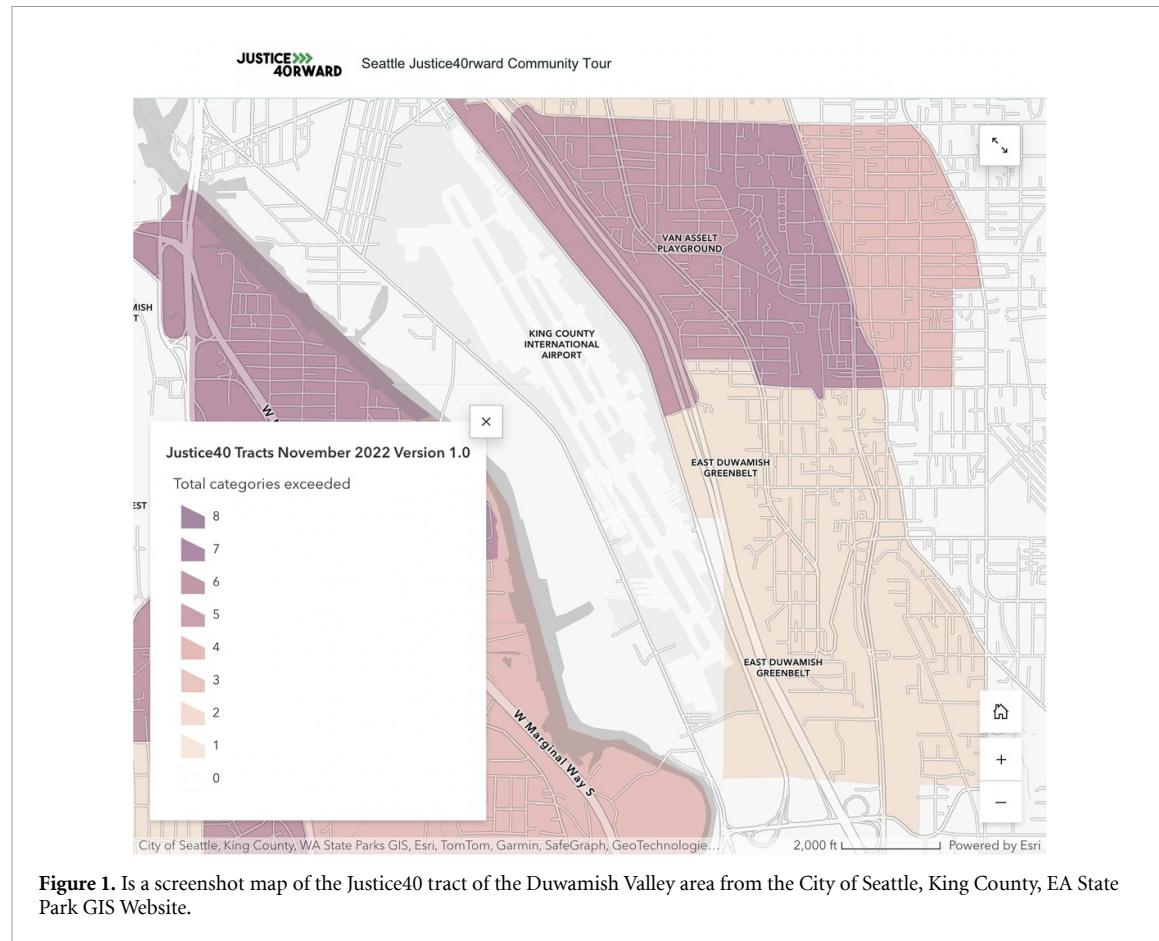
Similar work is happening outside of the United States. Greta Thunberg, who spoke at the United Nations Climate Change Conference in 2018, the World Economic Forum in 2021, the European Parliament in 2019, and the United Nations Climate Summit in 2019, [31] has famously pressured political authorities to address climate change. Other, less public examples are prevalent. Following the 2010 and 2011 earthquakes in Canterbury, New Zealand, a youth-led initiative called the Student Volunteer Army mobilized thousands of volunteers to support the disaster response actively [32]. The initiative helped families and communities who did not speak English or required more assistance with technological access to health and safety information, cleared debris from homes and buildings, and assisted older adults [32]. Youth engagement is also displayed through political action [32]. In 2019, 16 children and youth from different communities around the world filed complaints against the countries Argentina, Brazil, France, Germany, and Turkey through the UN Committee on the Rights of the Child, claiming that their best interests and rights to life and health have been violated by those countries' failures to mitigate climate change [20, 33]. In 2020, Fridays for Future, a youth-led and -organized global climate strike movement, proposed legislation to the European Union through the European Citizens' Initiative, setting more ambitious climate goals and financial support for climate action [20, 34]. Other global youth-led movements and organizations include the Sunrise Movement, the UK Youth Climate Coalition, Earth Uprising, Youth Climate Strike, SUSTYVIBES, and Extinction Rebellion [35, 36].

3. Study context

This study achieves the research objectives through the lens of two communities in Washington, USA, that are positioned to experience a disproportionate share of the negative consequences of climate change [37]. The Duwamish Valley (DV) community comprises the South Park and Georgetown neighborhoods in the City of Seattle. The area is designated as a Justice40 'environmental justice' community, impacted by air, noise, and water pollution exacerbated by its location near the lower Duwamish Waterway Superfund site [38] (see figure 1). The community is among the more racially and ethnically diverse in Seattle, with 55% of residents in South Park and 30% of residents in Georgetown identifying as non-white compared to 31% in the city overall, and is lower income with a median household income of \$34 605 in South Park and \$60 128 in Georgetown compared to \$74 458 in the city overall [39, 40]. In recent years, the compounding impacts of the climate crisis on this community have become increasingly evident, including wildfire smoke, extreme heat, and rising sea levels. These impacts are occurring in addition to existing health disparities; for example, lung cancer and asthma hospitalization rates for children and adults were disproportionately higher for the DV compared to the rest of the county from 2005–2009 [40]. The DV is expected to experience the impacts of sea level rise first and worst in the city, as evidenced already by a significant December 2022 flooding event [41].

Since 2001, the Duwamish River Community Coalition (formerly the Duwamish River Cleanup Coalition) has supported efforts toward EJ, including hosting the Duwamish Valley Youth Corps (DVYC) program [42]. DVYC is a youth engagement program that provides minoritized high-school-aged youth, such as young people of color, members of low-income households, students of low-income schools, immigrants, and/or non-native English speakers, opportunities to participate in EJ work. DVYC's work includes tree planting, neighborhood cleanups, restoration and maintenance work, invasive weed identification, rain garden construction, air quality projects, green wall construction, and implantation, and lessons about environmental degradation and EJ [42].

The Swinomish Indian Tribal Community (SITC) is a federally recognized tribe residing on Fidalgo Island in Western Washington State [43]. Although the Swinomish Reservation was established in 1855 by the Treaty of Point Elliott, the U.S. government has tried numerous times to redraw land boundary lines [43]. According to the United States Census Bureau, the SITC has a total population of 3 249 on- and off-reservation, with about 30% of individuals identifying as non-white and Indigenous. In 2020, non-white households (13% Hispanic/ Latine and around 2% Asian, Pacific Islander, and Hawaiian) had a median household income of \$53 750 compared to white households, whose median income was almost \$76 000 [43]. Of those identifying as Tribal households (roughly 7% of the population), around 26% are below the poverty level compared to about 2% of white households, and about 40% of Tribal households also use food stamps or government assistance [43]. See figure 2 for a map of the area.



The reservation is home to this Coast Salish tribe whose culture revolves around saltwater resources such as salmon, shellfish, and marine mammals, as well as land resources such as cedar and berries. However, rising sea levels, increasing temperatures, and wildfires threaten natural habitats, economic systems, cultural

resources, and human health [44]. For example, increasing inundation harms shellfish, leading to the loss of harvest sites. Shellfish, which include clams, crabs, oysters, shrimp, and mussels, are a culturally important food staple, and their deprivation can negatively impact the prosperity, health, and well-being of SITC members [44].

4. Theoretical framework

4.1. Health belief model(HBM)

The HBM theorizes how and why individual changes in health behavior exist and can be used to predict the decision-making processes that people use to engage in health-protective behaviors [45]. There are four key elements of the HBM: perceived susceptibility to health impact, anticipated severity of a health impact, perceived benefits of an intervention, and perceived barriers to executing the intervention [46]. An individual's internal motivation to improve their health is an additional factor in the model, although not essential. Together, these factors inform whether an individual will take health-protective actions. The HBM has steadily gained popularity in the disaster research realm, as the model can aid in understanding why individuals take specific measures during disaster mitigation, preparedness, response, and recovery. Some examples of disaster-related topics to which the HBM has been applied include the development of a disaster preparedness belief scale, [45] predictors of household earthquake preparedness [47], and assessing determinants of COVID-19 vaccine acceptance [48].

The HBM has been successfully used to study a variety of health outcomes among youth, including safe sex, [49, 50] smoking, [51] and obesity, [52] among others. However, to the best of our knowledge, there is a lack of studies examining youth perception of climate change risks, including extreme heat, using the HBM. Utilizing the HBM in this work provides a unique opportunity to explore current barriers, resource needs, and opportunities for youth to engage in climate and environmental solutions working in their own communities.

4.2. Intersectionality theory

The theory of intersectionality aims to understand how power, privilege, and oppression work in tandem to exacerbate inequitable socioeconomic conditions across populations and individuals based on factors such as personal identities (e.g. by race and gender) and conditions (e.g. housing dynamics, geographical location) [53]. The main facet of intersectionality is to interrogate the spaces of systemic oppression and discrimination to identify avenues to combat their historical impacts, address their contemporary presence, and create practical solutions for the future to address such compounded inequities [54]. Pat Hill-Collins describes transformational resistance towards social change as a strength and output of intersectionality [54]. Intersectionality offers numerous benefits as a framework for disaster studies because disaster events pose both social and ethical questions that must be considered when formulating hypotheses around the social dimensions of the disaster cycle [55–57]. Intersectionality is rooted in social justice movements, which is why it can help explain how disasters are socially constructed and how they affect marginalized populations [58, 59]. For example, intersectionality has been used to analyze the lived experiences of individuals experiencing homelessness during disasters [60] and how residents, recovery workers, and corporations fared after Hurricane Katrina [61]. However, the theory of intersectionality is also vulnerable to criticism. Scholars have questioned the operationalization and measurement of intersectionality because of its broad interpretations and applications across fields [53]. Some methodological approaches have instead introduced oppression into intersectional interpretations and understandings [53]. Additionally, some argue that intersectionality has lost its original political power and shifted from its origins rooted in social justice [53].

Throughout the disaster literature, individuals' race, age, gender, and class power relations, among other variables, play an essential part in understanding their social and health outcomes [55, 61]. Youth face multiple significant challenges during disasters due to their age and intersecting social identities, alongside formidable barriers to accessing essential information and resources, making it imperative to address and overcome these obstacles for their well-being [62]. In this study, we considered youth experiences through this lens of intersecting identities, a valuable way to assess youth's many life experiences.

5. Methods

Focus groups included discussions and interactive activities (including a Kahoot!™ Game and brainstorming activity) to ignite conversation. On 11 April 2023, the University of Washington Human Subjects Division determined this study to be human subjects research qualified for expedited review with minimal risk (STUDY00017572). The study was also reviewed and approved by the Northwest Indian College Institutional Review Board (Project Number: 2019–015).

5.1. Recruitment

We recruited study participants through established relational contacts with youth-serving organizations and communities in South Seattle and La Conner in Washington State, USA (see study context section).

Focus groups: We provided flyers about the event and background materials to community/youth leaders and staff members to facilitate discussion with prospective youth participants. The youth-serving organizations distributed the flyers and consent forms to the youth's parents/guardians, describing the nature of the project, potential risks and benefits of participation, and information regarding the \$25 gift card incentive for participation. The parents/guardians had at least two weeks before the scheduled focus group date to discuss the activity with their youth and return the signed consent form. Youth for whom parental permission was obtained were then provided with a description of the study before the scheduled focus group date and again before the beginning of the focus group. Youth were provided with an opportunity to give consent for their participation, and those who did not indicate a willingness to participate were not included.

Interviews: Prospective adult participants were identified in collaboration with youth-serving organizations and project partners. An email invitation was sent to each prospective participant, along with an overview of the project, offering a \$50 gift card incentive for their participation. We then emailed potential participants up to three times and worked with interested participants to schedule times for their interviews to be completed virtually or in person. Virtual participants were then sent a Zoom link and calendar invitation. Verbal informed consent was obtained before the beginning of each interview.

5.2. Inclusion/exclusion criteria

To participate in this study, participants had to be residents of South Park or Georgetown in the DV or members of the Swinomish tribal community in La Conner. Youth participants were members of the DVYC or Swinomish Boys and Girls Club and were between the ages of 13 and 18 years. Adult participants invited from these areas were youth and/or community leaders who (1) work directly or indirectly with youth or (2) work on climate adaptation or resilience planning or implementation. These participants included cultural preservers, local public health practitioners or government agency officials, directors, coordinators, and youth leaders of local non-profit organizations.

5.3. Data collection

We conducted individual semi-structured interviews with eight youth/community leaders and focus groups with 32 youth participants. Semi-structured interviews were conducted individually in person or by Zoom, depending on participant preference, between June and August 2023 and lasted between 35 and 60 min. One researcher (CJ) facilitated each interview, and at least one additional researcher (AK and/or GF) took detailed notes. To improve qualitative validity, we performed a member-checking process (see [Appendix](#) for data analysis plan) wherein interviewees were provided with a 3–5 page summary of key takeaways from their interview. [63] They were given three weeks to review the summary and provide any edits, which were subsequently integrated into the final analysis.

Four focus group discussions were conducted in June and July 2023 in person at local community centers where youth-serving organizing activities regularly occurred. Each focus group included four to eight participants and lasted approximately two hours, including some icebreaker games. Semi-structured facilitation was used to guide the interviews and focus groups. Two researchers (CJ and AK) facilitated the discussions and were accompanied by a notetaker (GF) and a youth-serving organization leader. Given the known impact of climate change on young folk's mental well-being, [10, 12, 18] each focus group discussion started and ended with a culturally sensitive mindfulness activity to ensure participants felt safe, grounded, and unharmed. As gamification is a fun and effective way to engage young students in climate and environmental education, [64, 65] youth participants played the online game Kahoot!™ as part of the activities, wherein they responded to a series of questions about their knowledge of and attitudes toward climate change impacts generally and in their communities. Subsequent facilitated discussion asked participants to describe experiences with climate-sensitive hazards, including heat, wildfire smoke, and flooding, and their perceptions of the health impacts of climate change, generally and in their communities. Participants then worked together in groups of 3–4 to brainstorm opportunities, wants and needs regarding communicating healthy behaviors, amplifying risks, and promoting climate leadership in their neighborhoods. They recorded their discussions on easels. The semi-structured interview and focus group guides asked similar questions. The interviews asked questions about their perceptions of youth experiences, risks, and opportunities for engagement. The HBM and intersectionality theory informed the interview and focus group guides. All interviews and focus group discussions except one (due to technical difficulties) were recorded and professionally transcribed. The research team then reviewed the transcriptions for accuracy.

5.4. Data analysis

Professional transcriptions and/or detailed notes taken during semi-structured interviews and focus group discussions were thematically analyzed using the Framework Method [66]. As an analytical tool frequently used in health and medical research, the Framework Method assists in identifying patterns, commonalities, and differences in qualitative data, explicitly homing in on the relationships between the narratives to help draw descriptive or explanatory conclusions into themes [66]. The HBM informed the development of a deductive coding scheme, supplemented by additional inductive codes created following the data familiarization process (i.e. reading and re-reading of transcripts and notes and discussion among researchers).

Each transcript was coded in NVivo 14TM qualitative software. Researchers (CJ and AK) coded 10% of the transcripts separately (two in total) and compared and resolved any discrepancies in the applied codes to ensure intercoder reliability. Additionally, researchers (CJ and AK) revised, clarified, or redefined codes during the co-coding process to enhance the reliability of the codebook instrument. A single researcher (AK) then coded the remainder of the interviews, while the other researcher (CJ) coded the remainder of the focus group transcripts.

Separate matrices were created for interviews and focus group data in Google SheetsTM, which were organized by case (row) and code (column). Code-level summaries from each interview and focus group were created by one researcher (CJ), audited by another researcher (AK), and entered into the matrix. Analysis memos synthesizing the code-level summaries were made, highlighting key themes across the interviews and focus groups. Afterward, we created a code network map for each research question that illustrated the relationships between the codes and how they interact to address the research question. Next, an analysis memo for each research question was created by one researcher (CJ) and audited by another researcher (AK).

For the focus group poster board activity, researchers (CJ, AK, and GF) reviewed the youth participants' responses to four questions to familiarize themselves with the data. To analyze these data, we conducted a content analysis wherein we summarized the content of responses to each question. Afterward, we constructed a matrix that included each case (poster board answers per session) and each question asked in the activity. The data were then entered into the matrix; one researcher (CJ) summarized the content by question across cases, and the other researcher (AK) audited the summaries.

6. Results

This exploratory research investigated the experiences of and identified opportunities for youth's active participation in climate and environmental solutions in their communities. Table 1 presents the results from the youth posterboard activity in line with our research questions. Table 2 presents key themes and sub-themes from the focus groups and interviews.

7. Interview and focus group results

7.1. Health impacts from lack of protective structures

Three main themes specific to health impacts were synthesized based on participants comments: (1) lack of green and blue infrastructures prevents the adoption of protective or adaptive health measures; (2) concerns for physical (e.g. asthma, cancer, COVID-19) and mental (e.g. anxiety, sadness) health; (3) compounding impacts of climate change amid existing environmental injustices. The following is a description of the themes.

7.2. Lack of green and blue infrastructure prevents the adoption of protective or adaptive measures

Most participants emphasized challenges that have made it difficult for their communities to adapt to extreme heat and accompanying environmental threats. Some challenges raised by youth and interview participants included a lack of green and blue infrastructure, like functional community spaces with ACs, urban tree canopies, clean waterways, and long-term cooling centers. The implications of these challenges for community members and vulnerable people, such as older adults, infants, and those who are unhoused, were a concern. Because of the recent frequencies of extreme heat, many homes in Washington require retrofitting to withstand extreme weather conditions, especially in EJ communities. This was frequently highlighted by the DV youth and Swinomish and DV interview participants. Other infrastructural needs include spaces for activities like basketball courts and pools, more transit options, improving school yards, water filtration systems, safe areas for water fountains that are not contaminated by toxic chemicals, and safe spaces for those who are undocumented, non-English speakers, low-income, and/or older adults. Participants emphasized that lack of access to such spaces has prevented youth and community members from taking proper

Table 1. Questions and Themed Responses from Youth Posterboard Activities.

Questions	Responses	Examples	Themes
Q1: How can we teach or communicate about climate change and environmental justice with our peers and community members? What would that look like?	<ul style="list-style-type: none"> Creating awareness on a local level Spreading information through art and media Providing opportunities for direct hands-on engagement Using AI/technology to create interest 	<ul style="list-style-type: none"> Holding events and gatherings for informational meetings Hosting bake sales Having door-to-door conversations (surveys) 	<ul style="list-style-type: none"> Sharing information and educating others by distributing through social media and community events
Q2: What types of roles can young people like you take to increase your community's ability to deal with climate change and its impacts, like extreme heat?	<ul style="list-style-type: none"> Promoting individual climate actions Invoking support through creative measures Providing exposure to climate-related occupations Conducting advocacy work Distributing resources 	<ul style="list-style-type: none"> Serving as communicators, preserving natural resources, limiting wastewater use, planting trees, reducing litter, and creating clubs. Creating challenges via social media Curating gatherings for young people Engaging in climate jobs 	<ul style="list-style-type: none"> Roles as initiators, communicators, leaders, and grassroots organizers; opportunities to engage in green jobs
Q3: What do you and your peers need to be a 'climate hero' in your community?	<ul style="list-style-type: none"> Social and economic support Supplies and resources Opportunities to participate in civic engagement activities 	<ul style="list-style-type: none"> Financial resources, space to connect and engage, connecting to social influencers and other youth orgs/youth leaders Craft supplies, food, gardening supplies; connections to educators and academics Access to computers and technology 	<ul style="list-style-type: none"> Increase in financial resources, connecting with social influencers, and power to create change
Q4: What impacts of climate change need the most attention in your community?	<ul style="list-style-type: none"> Lack of resources for extreme heat Urban heat island impacts Environmental injustices 	<ul style="list-style-type: none"> Increased access to fans, air conditioners, air filters, cooling centers/sprinklers, affordable and more ice Access to working and clean water fountains Lack of food security or food banks, masks, and other protective supplies for those experiencing homelessness 	<ul style="list-style-type: none"> Impacts of pollutants in land, air, and water; socioeconomic constraints in responding to threats

precautions. One youth participant explained that the events '*hit hard, it happens out of nowhere and impacts a lot very quickly, flooding makes people lose their homes, for heat waves, if people do not have water or shelter, it happens so fast.*'

7.3. Concerns for physical and mental health

While all participants emphasized issues affecting their communities' overall health, the adult participants specifically emphasized the negative impacts often shared by youth participants. For example, the youth often highlighted the physical impacts of extreme heat, including breathing difficulties and feeling lethargic, irritable, tired, and 'gross.' They also stated that they learned about the heat waves from their parents, and in response, they stayed home, sometimes in isolation, because options for cooling were limited. The DVYC youth participants highlighted personal health issues (e.g. asthma) and their fears regarding their families' susceptibility to other climate-related health threats like heat stress or skin cancer. For instance, one youth

Table 2. Themes and Sub-themes identified from interviews and focus groups.

Themes	Sub-themes
Health impacts from lack of protective structures	(1) Lack of green and blue infrastructures prevents the adoption of protective or adaptive health measures (2) Concerns for physical and mental health (3) Impacts of climate change compounding existing environmental injustices
Barriers, needs, and opportunities for youth engagement in climate action	(1) Social and financial factors (2) Perceived lack of power (3) Access to learning and training opportunities
Current opportunities for youth engagement in climate action	(1) Collaborative partnerships and interactive activities (2) Green training programs and field opportunities for exposure to climate work (3) Conversing with youth about climate action (4) Outreach and engagement

participant stated, '*My dad would go to work; still, my mom would be scared because dad works in his car and drives around.*' Another followed up, saying, '*My dad does painting and always outside, 6 am to 8 pm, just in the heat, me and my mom would be worried because he could get skin cancer.*' DV adult interview participants emphasized that the youth frequently shared these sentiments with them.

Adult interview participants noted that youth recognition of environmental injustices in their communities often causes feelings of sadness, cynicism, and disappointment or avoidance of the topic area altogether. One participant highlighted the difficulties DVYC experienced because of a locally polluted waterway, stating,

"It's bittersweet. It's hard for them to live so close to such a beautiful river that is so contaminated. There's a lot of—there's frustration and disappointment that, especially when we did the tour, for some of them, it was their first time on or in the water. And for some of them, they didn't know that there was a river so close by to where they lived. And to see it and not be able to get in it, to them, it's just disappointing that it's there and it's being polluted. And yeah, there's a lot of that sentiment of like, 'Dang it.' It's like, 'I want to jump in, or I want to go swimming, but I can't.'

These environmental injustices, in addition to climate impacts, have had cascading negative impacts on youth's mental health. DVYC youth participants highlighted feeling uncomfortable, agitated, or depressed during events due to limited spaces to alleviate the effects of extreme heat. One youth participant stated that during extreme events, '*I lowkey got a little depressed. I do not know why.*' Another responded, saying, '*Because you cannot do anything, go out. You cannot be with friends. You mostly stay inside.*' Another finished by saying, '*it is sad because you do not know what's going to happen the next few years or what's going to happen in the long run.*'

In validating the youth sentiments and recognizing their implications, adult participants from both areas emphasized the need for mental health resources. One DV interview participant stated,

"I think more mental health resources or more conversations around mental health and stress and how to cope with issues like heat waves and climate change, wildfire smoke. I think that it's all happening so suddenly and so frequently that it can be overwhelming and can take a toll on their mental health, especially from conversations that I've had with them; things at school can be challenging sometimes with bullying. And it's just they've been going through it, and I feel very honored as a person that is in their lives who can offer support as a friend or someone to talk to, but I think they need more of that, just more support and more resources."

7.4. Compounding impacts of climate change amid existing environmental injustices

Youth and interview participants repeatedly discussed cultural and community factors that compound their experiences navigating environmental and climate-sensitive hazards. For instance, one tribal participant shared a traditional story about a cedar tree, emphasizing the cyclic and reciprocal relationship between family dynamics, protection, and navigating different weather patterns. Tribal culture and practices are rooted in the environment. Considering accelerating climate events and their impacts on health-related risks,

tribal participants worried that their traditions face extinction as they cannot navigate in the same ways they have for years (e.g. taking canoe trips, fishing, digging for shellfish, or conducting their ceremonies outdoors). With the loss of tribal engagement practices, the intergenerational stories that are intricately woven with the environment stand to lose meaning, and therefore, solutions for addressing these issues become complicated.

As a result, interviewees are more concerned about climate-related health impacts that they or their community members may experience, including elders and others with respiratory illnesses and other conditions. All participants expressed the need for community members to be in a constant preparation mode and understand their limited capacity to respond to all of the concurrent health risks, showing the additional stressors these youth must navigate. Additionally, all adult participants noted that youth lacked a robust understanding of the severity of climate change, the vulnerability of the youth and community members, and the cascading health impacts of climate change. An interviewee from DV summarized their concerns about how folks respond to these compounding exposures and impacts, given the preexisting risks and barriers they face.

“We already have the highest asthma rates. We already have pulmonary disease. And because we’re smelling everyday these horrible metals, chemicals, and highways, diesel. So one thing that I always say is we’re juggling different things, and we don’t know if opening the windows is better than closing the windows because also we have problems with indoor pollution, right, with homes that are not safe for the community to be breathing in. So, yes, they are prepared. We are prepared. But yes, we are not prepared. So it’s complex because of the speed of things happening [from] the climate. I think everybody’s thinking climate change is coming in 20 years. It’s here now, and everything that we’re doing, we’re attributing to—unseen, we’re attributing to climate already, so.”

While there are nuances between youth’s perceptions of climate impacts and the severity of such impacts, they all recognized that the weather has changed from when they were younger to recent years. Interview participants highlighted that while the youth have acknowledged signs of shifting weather patterns and the health impacts of past events, they urgently need to understand the long-term consequences of the changing climate.

7.5. Barriers, needs, and opportunities for youth engagement in climate action

The following discusses three themes that were synthesized from focus group and interview participants’ feedback regarding barriers, resource needs, and opportunities to promote youth engagement in climate action: 1) social and financial factors; 2) perceived lack of power; and 3) access to learning and training opportunities.

7.5.1. Social factors and financial barriers

Participants from both communities identified multiple social and financial factors that inhibit youth and community members from participating in environmental and climate-related work. Participants explained that inclusive educational programs for youth would help build the workforce and promote the community preparedness necessary for future climate events. However, factors like peer pressure and bullying, gangs, crime, and drug use often negatively impact youth if they are not consistently supported by positive role models. Additional social factors reported to inhibit youth engagement include immigration status (e.g. from East Africa, Southeast and East Asia) or refugee status (e.g. escaping famine, political/civil war, genocide.), speaking a language other than English, and a lack of climate/environmental-focused curriculum. These identities often face unjust stigma due to the increasing anti-immigrant sentiments and laws. As a result, their ability to access essential needs and pursue social and economic progress is hindered [67–69]. Participants highlighted access and functional needs that limited engagement, including reliable transportation options, resources for non-English speakers, and paid training opportunities for undocumented youth. Participants also highlighted systemic issues like racism, housing, and economic disenfranchisement (i.e. being low-income and having to work to help families) that limit youth capacity to engage in climate-related work, especially in the long term. Financial factors that were reported to limit youth capacity to engage in climate action included financial resources to support training and programmatic opportunities in each community. While the youth programs offer participants different opportunities to do activities like laying sandbags to protect homes from flooding and foraging for traditional herbs for medicine, adult participants from SITC and DV frequently emphasized the need for financial resources to support equitable access to programming. For instance, one interviewee from DV stated,

“For one program, I think we pay for the engagement and placement of 25 youth per cohort. There’s three cohorts that they run a year. And every time that they have a new cohort, I have heard that up to 70 youth shows up, right? And I don’t know if they have the funding to do that, or the capacity

even, right? Because there needs to be staff who facilitates and, convenes, and supervises. So, I think funding is a big need. I think education is a big need.”

Such funding limitations were reported to impact (1) how many young people the youth leaders can engage with, (2) how often or how long they can maintain their participation, and (3) access to information necessary for youth education.

7.5.2. Perceived lack of power inhibits sustained youth engagement in climate organizing

Youth and adult participants emphasized that a lack of support for youth/community perspectives deters young people from being active, interested, or engaged. For example, one DV participant emphasized that the youth have this constant ‘*feeling like they are not being heard*,’ which prompts youth responses like ‘*Well, what can I do? i am not the one in charge*.’ This participant went on to say that the young people ‘*have great ideas, and they just feel like they are not being heard by the people that can influence that change. And yeah, just feeling—I do not know. It is stressed out or depressed or stuck that they keep hearing this message of climate change is real, it is here, it is happening, and it [is] just feeling like an uphill battle*.’ Many adult interview participants shared this view. In response, youth and interview participants emphasized needing political backing to address the needs of their communities. In DV, particularly, the youth frequently speak to local government officials about their concerns. Still, based on their experiences, the youth have expressed ‘cynicism’ and mistrust.

“A lot of the feedback came from what I would see as a place of cynicism. But again, it’s very much rooted in reality, where some of it was like, why are you asking us these questions? Are you only doing this so that this neighborhood can become nicer and then become gentrified, and we can’t afford to live here anymore? What are your real motivations for asking the community for their feedback? Do you really want community feedback? Are you really going to listen to us? ... And they spoke pretty openly about distrust of how the government can handle these kinds of climate events and how the government can step in and change up neighborhoods in preparation for them in the future.”

Swinomish youth participants often deferred to adult decision-makers to respond to the community’s issues as they, too, felt they had limited power to make change.

7.5.3. Access to hands-on learning and training opportunities is necessary to support youth engagement

Participants emphasized that long-term engagement and educational opportunities available for youth yield many cascading benefits for a community’s growth and resilience. Such opportunities include exposure to green jobs and foraging activities for food and traditional herbs for medicine, increased volunteer efforts, enhanced leadership skills, and increased awareness of climate change impacts. However, as one interviewee stated, this is

“pretty challenging, but I think it comes down to us as a community needing to make that space available for our youth and our children. Let them know that we believe in them, that we support them, that we can empower them and give them the tools and the skills that they need to be successful, to be active, contributing citizens to our society because that’s their role. They have their purpose, and we just need to support that and grow that the best that we can. And I feel like we have the infrastructure in place. It’s just getting more of the workforce on board to be trained to work with the youth.”

While youth participants said they would speak briefly about climate change in their classrooms, they reported limited incentive to engage in climate action. Classroom discussions alone were reported to fall short of motivating students to take action. As one DV youth participant put it, ‘*I already knew a lot of the stuff from class and this program. So for me, you could learn about it, but you actually have to put in that effort in order to follow through*.’ With the need for action in mind, youth and community leaders have worked to engage youth participants in various ways, like workshops in community gardens and along local shorelines, but these leaders emphasized that historically rooted and culturally influenced community traumas contribute to a lack of engagement. For instance, one Swinomish interviewee spoke on the historical marginalization and experiences of the Indigenous community, saying, ‘*We have a lot of healing that needs to happen within our own families from the traumas that we have experienced with boarding schools, with colonization itself. And so it makes it really challenging to have those expectations of the children and the youth when they have never been uplifted in that way, when they have never been given the skills*’.

Overall, youth focus group and adult interview participants suggested that more intentional collaborations with local organizations, schools, social media influencers, government officials, and community programming for youth would provide collaborative learning opportunities and also encourage

more youth to participate in climate and environmental-related projects. Such partnerships would relieve educational barriers and provide opportunities for long-term sustainable practices like building up food systems, understanding heat-related illness, and sharpening community development skills. Participants suggested, however, that these partnerships and experiences should acknowledge community trauma and challenges and emphasize the importance of youth participation, youth perspective, and youth-driven solutions.

7.6. Current opportunities supporting youth engagement in climate action

The following discusses responses that interview participants spoke about regarding existing opportunities to support youth engagement in climate action. Opportunities identified through their responses included: (1) collaborative partnerships and interactive activities; (2) training programs and field opportunities for exposure; (3) conversing with youth about climate action; and (4) outreach and engagement.

7.6.1. Collaborative partnerships and interactive activities

Participants reported that they and fellow youth leaders lead different activities for young people that support social connections with each other and other community members, green jobs, and community resilience, including through university partnerships. Youth participants learn skills like state and local policy advocacy, community engagement, and environmentally conscious lifestyle choices. In DV, one participant described the types and impacts of their activities:

“We did art, how art can help mental health, expression through art. We did physical activities, spending time outside, [and] how that can have a positive impact on your mental health. We did movement. We did gratitude journals. So that was really, really fantastic. And we’re going to try to weave that into our next unit with the UW nursing students. Although I do think it is going to be very important to talk about the health effects of wildfire smoke, I think we’re going to try and have some continuity there with the mental health element as well.”

SITC has created a clam garden, which allows youth and other community members to contribute in a long-lasting way. A clam garden is an ancient Indigenous technology of building low-lying rock walls below mean low tide on the shoreline to create terraces, increasing habitat for clams and other sea life. Indigenous peoples have tended these ‘gardens’ along the Pacific Coast for thousands of years. One Swinomish participant stated that

“the clam garden is hands-on. That’s a great opportunity to teach them. And some people just want to—oral, talk to me. I mean, listen and hear. And some people are just visual, show me how this is—how this is going to benefit others. It’s not all at the same time, but it gets put out there with our youth in our community and have—this is what we need to do if your kids want to eat their traditional foods. And a lot of us here do eat our traditional foods. So to them, like, oh, I need to pay attention to this more.”

Youth leaders noted that long-term educational programs allow for more time with the youth and strengthen community solidarity and connections. As participants from both areas highlighted, participating in intentional, consistent, and inclusive sustainability projects and committing to restoration work and outdoor activities help youth engage with environmental issues. One DV participant, for instance, highlighted the benefits of their current program, saying,

“So a lot of the programs that I worked on before are, yeah, two weeks or six weeks at the most. So this is a yearlong program, which is a large time commitment from the kids, but I think it really solidifies that community they have with each other and also with myself and the other mentors and adults in the program. So I think that’s a really big one is just like meeting very regularly for a good amount of time to create those community connections. We’re going to start doing some more restoration work... I do think it’s really special when youth can get outside and really connect with the land, especially when we’re talking about all of these big, huge, nebulous issues all the time. Just putting your hands in the soil, I think, is really, really useful, and then connecting that back to the larger issues the whole program is about is really helpful.”

7.6.2. Conversing with youth about climate action

To encourage young people to participate in climate action within the community, participants suggested providing them with a safe environment needed to voice their perspectives on the things that impact them directly. This includes having honest dialogues about past traumas and current dilemmas, as well as creating spaces for youth engagement. Emphasizing the importance of conversing with the youth about the intersections between climate justice and social justice, a DV interviewee said,

“For us, it’s not complicated conversations because climate is air pollution, right, climate is health. So, we started the conversations differently. If climate resilience for them means, let’s talk about how scared we are to walk on the streets or the increase of violence in the streets. There was a point that there were some shootings happening that parents ... were just too concerned to let kids walk around the neighborhood. So that, to us, means talking about climate. So, we let them lead with what is happening right now. What’s going on? What’s in your head? And then we start kind of shaping the conversations in— but we always let them lead what they would like to discuss. And so for us, it means climate resilience means all of that.”

One tribal interviewee reiterated this sentiment and provided additional context on the value of youth perspectives:

“Because a lot of our young people, once they start voicing themselves on what they see that needs to happen, our people are listening. We listen to them because what they’re saying is honest and true. They don’t have a lot of segue of people influencing them. It’s what they’re saying from their hearts. And this is what they’re seeing with their own eyes. So, believe it or not, they have more power than anybody else because of what they— because they’re so young. And they’re not being influenced. They’re saying what they have to say from the heart. And they are just seeing it through their own eyes. So they actually have a lot of power that they just don’t know because they don’t use their voice.”

Adult interview participants shared how youth experience a multitude of stressors, including violence or trauma related to boarding schools, which require leaders to meet youth where they are when engaging with them. Participants noted that they had identified opportunities to discuss the intersectionality of violence and climate change with the youth.

7.6.3. Training programs and opportunities for exposure

Adult interviewee participants noted that providing youth with varied opportunities for direct training could build community resilience, determine youth roles and responsibilities, and promote autonomy and leadership when addressing the health implications of climate change. As one Duwamish participant suggested,

“I think engaging them in discussion around planning and having other programs that are working on this, especially medical because they would bear the brunt of it, to start engaging with youth about emergency planning and what would your role be because you’re young and healthy and you need to help your older folks that need help. How would you go about doing that? And just see what kind of— just start asking them what would they do? And maybe they don’t have an answer, but get them to start thinking, ‘What would I do?’”

One Swinomish participant reflected on their experience training with the local Community Emergency Response Team. They suggested youth participate in a 40 h youth-focused training where

“police and fire could implement that because they have lots of trainings going on already. But to engage the youth in maybe some sort of summer training program for a week where they would learn about what to do if an earthquake happened, what to do if a tsunami happened, what to do if there’s a major smoke event or heat event, and just have every summer training on that for ages 6 through 12th grade.”

Another interview participant highlighted offering training to youth participants in DV to understand topics such as building infrastructures and resilience in their communities. Through this education, the youth distribute knowledge in multiple ways: (1) gain experience communicating technical terms and concepts to their peers, (2) interests and leadership skills are promoted, (3) youth social networks are recognized, utilized, and expanded upon, and (4) participants get public speaking experience by presenting ideas and projects in which they participated. According to this participant,

“I am working on this effort to establish a resilience district in the Duwamish Valley. And part of it is, how do we build physical infrastructure to protect communities from overtopping the Duwamish River?... So this is one of the projects where we have asked the youth to help us do outreach and engagement on. So my teammates and I have gone to youth, and we have explained these complex things and how it relates to climate resilience. So that then, they, when they host climate forums or environmental justice forums, they are the ones presenting and gathering information from their neighbors and peers and families on the resilience district.”

7.6.4. Outreach and engagement increase climate actions in the community

Interview participants provided various examples of the power of youth voices, especially when connecting with other people through in-person (e.g. school) and virtual (e.g. social networks) means. As one DV participant put it, '*... [the youth are] in this really unique position where they have been in this area that is an area of environmental injustice. And they know so much about it. That's so amazing that they know so much about these super, super complex topics at their age.*' Youth have direct access to peers, elders, schools, siblings, and parents, and they also have the power to influence and engage on platforms like Twitter and Instagram, as seen with recent youth-led climate movements. Indeed, youth focus group participants described several opportunities to engage their networks about climate action, including building public awareness and utilizing digital resources, such as videos, blogs, or social media posts, to create informative campaigns raising awareness about climate and health disparities. However, interview participants also noted that youth may not recognize their influence and its potential to effect change.

Beyond youth influence, youth and adult participants alike suggested that having local celebrities, influencers, or even their own peers speak to the youth about the importance of climate action would increase interest in the work. These methods of engagement, which have been successful in social justice movements, were described by a participant as having the potential to create a feeling of collectivity and support, building awareness and disseminating knowledge on the issues that are impacting youth. One DV participant described the power of peer sharing:

"Sometimes we'll collaborate with other community centers or their high schools or their middle schools if they're doing some kind of a presentation or a youth forum. Earlier this year, we attended an environmental science symposium that a local high school was putting on, and just bringing our youth to meet more youths that are doing similar work, sharing what they've learned, how, where they learn those things, and sort of widening the network of places that our kids have to go to learn more and be able to engage."

As one Swinomish participant said, 'Young people have a lot of energy. I think that's probably one of their biggest assets.' Another participant from DV noted that youth are motivated and fulfilled by their ability to support their neighbors. They shared their experience from a recent climate-related event:

"They were interested in supporting their neighbors who were living next to the river. And they were like, '[name redacted], can we go help with sandbags?' And that was such a great thing because it was very physical. It was right on the river. But they were so feeling like they almost changed the world because families were very grateful. Sandbags were like 40, 60, 100 pounds and full of sand. Put them in there. And they were like, 'Oh, no, now there won't be flooding.' Of course, the King Tide didn't come back the way it did, but they helped the community be prepared. So that will be like, 'Oh, my gosh, we could do something about this,' ... They own that piece of helping neighbors be safer and that they can contribute."

8. Discussion

This exploratory study identified challenges to and opportunities for youth to become involved in climate change and environmental solutions in their communities. This project explored mechanisms to enhance coordinated action, build community, and promote personal autonomy and leadership by speaking with youth directly to understand their perceptions of health risks and identify opportunities for youth to engage in climate and health solutions. Our study's results can inform approaches to youth engagement in climate change action. In line with the literature, we found that youth were well aware of their possible roles in response to climate-sensitive events (e.g. extreme heat) and opportunities for their involvement in environmental solutions.

Our findings also reveal several barriers to youth engagement in climate action, often exacerbated by intersecting socio-economic issues that amplify youth's vulnerability to climate-sensitive events. However, we also find opportunities to address these barriers. Both youth and adult participants emphasized the need for capacity building, recognizing the value of the knowledge that youth possess, their concerns regarding current impacts, and their ideas for the future. For example, youth reported lacking support for and/or validation of their roles and perspectives regarding climate action. Youth attributed this lack of support to both age differentials and existing power dynamics, which cause them to feel overshadowed and excluded, ultimately limiting their interest in or ability to participate in climate action or EJ work.

Adult interview participants described limited opportunities to engage youth in climate-related work, expressing that they have limited financial and staffing resources to engage with the youth in this type of work, especially in the long term. Despite increasing exposure to climate events (e.g. king tide floods) and

anthropogenic events (e.g. airborne chemical spills), they reported limited local expertise and conflicting community interests. They have adapted their programs to engage the youth through hands-on experience and activities in response to interest from local, state, and academic partners. For example, youth leaders created programs focused on green jobs and training programs, creating space for conversations about specific community dynamics (i.e. drugs, mental health, and climate justice). They also created food system improvement (i.e. bringing a clam garden to the reservation) and collaborated with local organizations to increase administrative capacity to support young people in long-term sustainability activities better.

Studies have shown that youth may avoid engaging in climate discussions, activism, and resilience work as a psychological defense mechanism. [70–72] Education on climate change alone can induce climate grief and eco-paralysis, especially among marginalized youth who have dealt with its impacts all their lives. Youth participants DV described feeling depressed, lethargic, helpless, and apathetic because of extreme heat events. They also highlighted disconnection from family members since everyone was 'on edge' and uncomfortable without fans, AC units, air filters, and other resources needed to adapt.

While our study only included one tribal community, our results point to differential impacts of climate-related events on Indigenous youth due to differing cultural norms and perspectives on health. The SITC previously developed a set of community-based 'Indigenous health indicators' that use its worldviews to conceptualize and measure health, going beyond the Western emphasis on physiological health. [73] Indeed, when asked about health impacts, tribal participants in our study often emphasized how their cultural dynamics continue to be disrupted by environmental events. Events and activities such as community clam bakes, agricultural work, fishing, crabbing, foraging, and connecting to the land have been compromised. As adult participants highlighted, these disturbances cause concern as many of their traditions, stories, food systems, values, and motives are tied to nature. Supporting tribal youth will require accounting for these divergent perspectives, including hyperlocal engagement and the resources to support it.

Our study benefited by utilizing a framework that pulls components from a social justice and decolonization lens cognizant of these groups' historical and cultural dynamics. Intersectionality helped us to look at these different identities and what they mean for youth's ability to adapt to a changing climate, given past and current experiences with racism, economic disenfranchisement, and unequal political power. Tribal participants frequently highlighted the collective trauma and violence that their community is healing from due to the impacts of boarding schools [74] and the dynamics of land sovereignty. This is compounded by environmental impacts like the death of shellfish in 2020 from the heat dome and those subsequent impacts on their cultural dynamics. In the DV, navigating the effects of redlining, gang violence, and living on a Superfund site, [75] coupled with limited green and blue infrastructures to protect from events like flash flooding and extreme heat, has directly impacted the community's capacity to address upcoming events, as it is in a constant state of recovery from previous and ongoing disasters. Successful youth engagement in climate action will require efforts to create safe, inclusive, and empowering spaces that recognize these intersecting stressors.

9. Recommendations for youth engagement

Engagement in climate action and community resilience involves more than just incorporating youth voices and perspectives—it requires collaboration, capacity-building, organizing, granting decision-making power, and other opportunities to produce inclusive, intersectional, and productive solutions. Based on our results and through our perspective as leaders in community-based organizations (PL, CP, and CM) and tribal government (JD), we make the following recommendations. To evaluate their effectiveness of implementation and impact, we recommend holding regular feedback sessions and using structured assessments (e.g. surveys) to (1) measure youth participants' knowledge and progress and (2) evaluate the youth program or workshop's impact on youth's well-being, skill-building, and engagement opportunities.

9.1. Create opportunities for sharing knowledge

Participants frequently emphasized the importance of education. Studies have shown that youth learn best about the environment in settings where they can be hands-on with the curriculum in their schools and communities and learn directly from their elders, parents, and friends. [7, 76, 77] In line with the literature, we encourage youth leaders to develop curricula integrating environmental and social justice issues, public health dynamics (including mental and emotional health resources), and topics related to climate science. Collaborating with educators and academics, other subject matter experts, and community organizations can ensure that such curricula meet state standards, the needs of youth, and local needs. Incorporating field trips to community initiatives that are contributing to climate adaptation and/or response to climate-sensitive hazards, including renewable energy facilities, healthcare centers, and urban gardens, can support engagement by exposing youth to real-world applications for classroom content.

9.2. Center youth-led activism and advocacy efforts

Many young climate leaders (e.g. Haven Coleman and Jerome Foster II) have used civic engagement to effect change [78]. As youth participants often felt that most of the power is held by government officials, we recommend encouraging youths to identify local environmental and health issues and advocate for policies to address them on a local, state, and federal level. Youth organizations can support discussions of and training on policy advocacy, culturally and socially sensitive engagement, and personal and community-level approaches to climate mitigation (e.g. greenhouse gas emissions reduction) and adaptation. Potential activities include helping youth create multimedia information campaigns using tools like videos, blogs, and social media posts to raise awareness about climate and health disparities. Providing spaces for youth to present or share the outputs of climate action activities and campaigns, such as online platforms, community meetings, local newspapers, and social media, can support youth's perceived self-efficacy, particularly for members of underrepresented groups.

9.3. Develop meaningful collaborations and engagement practices

Recognizing the limited capacity of under-resourced community members to secure funding and sustain collective climate work, we recommend forging partnerships with local environmental and health organizations to organize youth-centered or youth-led workshops on climate change, health disparities, and EJ. Guest speakers, community banks, climate scientists, local public health professionals, university students, and community activists can come to the workshops to share their expertise. Events like this also allow young people to discuss and share their experiences with community and government leaders, which can (1) create networking opportunities between interested parties and youth, (2) expose youth to multiple perspectives and approaches to addressing climate and health impacts, and (3) encourage partnerships to support youth-led requests, needs, and solutions. Additionally, we recommend designing community-centered, youth-led climate action projects through collective brainstorming with community members. Project descriptions should include plans to acquire funding and other resources, recruit dedicated educators and mentors, and identify and address potential obstacles before and during project implementation.

10. Strengths and limitations

Our study's community-rooted, mixed methods approach has several strengths that can be adapted for future research with youth on climate-related issues. We worked alongside youth and community leaders to identify successful techniques for engaging youth based on their past experience, as well as to understand the basics of local youth perspectives on climate change, EJ, and the health consequences of climate change. We sought to respect and integrate participants with different learning styles, education levels, personal identities, backgrounds and past experiences, and cultural influences. We also sought to create an inclusive space to maximize engagement with the youth, encourage more responses, and empower participants to come up with solutions to pertinent environmental issues in their community. We used a Kahoot!™ game to make participation fun and encourage interest in the discussion. The game triggered discussions of past experiences and opportunities for future activities. These multimodal opportunities for engagement, including group discussions, poster board activities, and Kahoot!™ game helped to build rapport with the youth and allowed them to be more engaged based on the mode they were more comfortable with.

This study has a few limitations. While the HBM was used to design the focus group guide and coding scheme, youth often did not explicitly talk about their perceptions and ideas in the context of the framework's domains, requiring researchers to make reasonable inferences when coding. Youth-specific frameworks may be more useful for future studies. Moreover, our study was limited by a relatively small sample size. We attribute our limited sample size partly to delays experienced in Institutional Review Board (IRB) approval and suggest substantial time be allocated to securing such approvals in future studies, particularly those seeking multiple and/or tribal IRB approvals. Finally, as our study setting was limited to two Washington communities, results may not be generalizable elsewhere.

11. Conclusion

Previous literature surrounding youth's responses to disasters has called for repositioning young people from passive victims of their circumstances to active participants. However, youth's voices and experiences remain underrepresented in climate-related activities and decision-making processes. Through key informant interviews with youth leaders and focus groups with the youth themselves, our study identified the powerful benefits of engaging youth in climate action. Youth participants in our study reported awareness and understanding of social and environmental issues, concern for the well-being of their communities, and willingness to learn and grow as leaders and activists, which were affirmed by the youth leaders interviewed.

We also identified barriers to youth engagement in climate action, including limited resources and opportunities. However, policymakers, government employees, community-based organizational leaders, and others should unite with youth as allies to support capacity-building, organizing, decision-making power, and other opportunities to produce inclusive, intersectional, and sustainable solutions to climate change.

Data availability statement

The data cannot be made publicly available upon publication because they contain sensitive personal information. The data that support the findings of this study are available upon reasonable request from the authors.

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Appendix. Youth Heat Project Data Analysis Plan

Interviews & Focus Groups

1. Transcription
2. Data familiarization
 - a. Researchers (CJ and AK) will review the cleaned transcripts and read through them in their entirety to familiarize themselves with the data.
 - b. To further familiarize with and ensure the validity of the data, they will put narratives into a summary memo for member-checking purposes. Once the first researcher constructs the memo (CJ or AK), the rest of the team will review the summaries for accuracy before sending them to study participants for any feedback. Member checking memos will be sent to study participants within two weeks of the conducted interview. If study participants had any clarifications, these were incorporated into the memos to ensure validity.
3. Coding and Codebook development
 - a. The HBM informed the development of the initial coding scheme (deductive codes) and was supplemented by additional codes created following the data familiarization process (inductive codes).
 - b. The researchers (CJ and AK) will first code 10% of the transcripts separately (two in total) and compare and resolve any discrepancies in the applied codes to ensure intercoder reliability and to identify emergent themes. Additionally, to refine the codebook, the researchers (CJ and AK) will revise, clarify, or redefine codes during the co-coding process where necessary to resolve any discrepancies in code definitions.
 - c. An open/inductive coding method will be used. After co-coding is complete, one researcher (CJ) will code the remaining transcripts.
4. Thematic analysis
 - a. The framework method [66] will be used to organize and thematically analyze the data.
 - b. Separate matrices will be built in Google Sheets for the focus group discussions and the interviews. The matrices will be organized by case (interview or focus group transcript) and codes. One researcher (CJ) will first create code-level summaries from each interview/focus group, which will be audited by another researcher (AK) and entered into the matrix. An analysis memo synthesizing the code-level summaries will be created, highlighting key themes across interviews/focus groups.
 - c. For each research question, we will create a code network map that illustrates the relationships between the codes and how they interact to address the research question (listed below). Next, one researcher (CJ) will create an analysis memo for each research question and audit it by another researcher (AK).
 - i. What are the health perceptions of secondary school-aged to ongoing climate change and environmental-related hazards in their community?
 - ii. What are the barriers, sources needed, and opportunities available for secondary school-aged youth to engage in solutions work related to ongoing climate change and environmental risks?

- iii. What methods have youth and community leaders used to support youth-led initiatives related to/or addressing ongoing climate change and environmental risk?
- d. These final narratives will be used to develop the results section of the manuscript.

Poster Board Activity

1. Data familiarization (responses to 4 poster board questions)
 - a. Researchers (CJ, AK, and GF) will review the youth participants' poster board responses in their entirety to familiarize themselves with the data.
2. Content analysis
 - a. The researchers will conduct a content analysis using poster board questions to further familiarize themselves with and ensure the validity of the data.
 - b. A matrix that includes the case (poster board answers per session) and each question asked in the activity will be constructed. The data will be entered into the matrix for the poster board activity, and one researcher (CJ) will summarize the content by question. The other researcher (AK) will audit the summaries. The content summaries will be provided in a final table.

Kahoot!™ Game

1. Pending results from the previous analyses, the Kahoot!™ Game results may or may not be included in the final analysis. If they are, results will be downloaded from the website into an Excel spreadsheet. Data includes scores, time spent on each question, and other open-ended responses.
2. The researchers will consider creating a demographics table to give the reader an understanding of the participants' knowledge base or understanding level. Multiple choice responses will be tracked, and a summary of the scores will be used to highlight prior knowledge or awareness of climate-related issues. A final diagram highlighting the connections between responses may also be provided.

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