REVIEW ARTICLE

FACTORS ASSOCIATED WITH CARBON TAX AWARENESS: A SYSTEMATIC REVIEW

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ABSTRACT

Carbon dioxide is the primary greenhouse gas responsible for approximately three-quarters of the world's gas emissions. Carbon dioxide (CO_2) is an important heat-trapping gas, or greenhouse gas that comes from the extraction and burning of fossil fuels. Its presence in the atmosphere warms the planet, but the rising concentration of greenhouse gases has led to climate change due to hotter temperatures across the globe. Carbon tax is defined as a fee imposed on the burning of carbon-based fuels, such as coal, oil, and gas, which aims to reduce greenhouse gasses. Thus, this study aimed to evaluate the factors associated with carbon tax awareness among the general population. This systematic review aimed to systematically evaluate factors associated with carbon tax awareness among the general population. A systematic search was conducted in Scopus and ScienceDirect. This review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The literature search was conducted from 1st November until 1st December 2022 using Scopus and ScienceDirect databases. The following keywords were used to search for related articles: "carbon tax policy" AND "awareness" AND "factor" OR "factor associated". All retrieved articles were imported into EndNote20. A total of two studies met the inclusion and exclusion criteria, with one eligible article from Taiwan and 1 from Canada. The analysed articles were published between 2020 and 2022. The identified associated factors of carbon tax awareness, namely trust in the federal government, climate change concerns, environmental concerns, education, health consciousness, and age, can be used as a guide for designing evidence-based measures and policies that address these concerns.

Keywords: *Carbon tax, awareness, associated factor*

INTRODUCTION

Carbon dioxide (CO_2) is the primary greenhouse gas responsible for approximately three-quarters of gas emissions around the world. Greenhouse gas emissions consist of carbon dioxide from fossil fuel and industrial processes (65%), nitrous oxide (6%), methane (16%), and carbon dioxide from forestry and other land use (11%)[1]. CO_2 is an important heat-trapping gas, also known as greenhouse gas that comes from the extraction and burning of fossil fuels (e.g., coal, oil, and natural gas), wildfires, and natural processes (e.g., volcanic eruptions)[2]. However, excessive CO_2 in the atmosphere is warming the planet and causing climate change. Climate change refers to long-term shifts in temperatures and weather patterns that may be natural, such as through variations in the solar cycle. However, human activities since the 1800s have been the main driver of climate change, primarily due to burning fossil fuels[3].

Climate change is impacting the world via hotter temperatures because of the rising greenhouse gas concentrations. Higher temperatures exacerbate heat-related illnesses and makes it challenging to work outside. When the weather is hotter, wildfires can start more easily and spread more quickly. The Arctic has warmed at least twice as quickly as the rest of the world. Climate change can also increase the duration of draught due to changing water availability, thus, making water scarce in more regions. In many areas, destructive storms have increased in ferocity and frequency. More moisture evaporates as temperatures rise, which exacerbates extreme rainfall and flooding, leading to more destructive storms. Other effects include loss of species, and increasing rise in hunger, and poor nutrition among the affected populations. Climate change can affect health and exacerbates factors that cause and maintain poverty. For example, urban slums could be swept away by floods, destroying homes and livelihoods. Outdoor labour can be hampered by high temperatures, while water scarcity may have an effect on crops. During the last decade, weather-related events have displaced an estimated 23.1 million people annually, leaving many more susceptible to

poverty. The majority of refugees originate from the most vulnerable and least prepared nations to adapt to the effects of climate change[3].

Carbon tax is defined as a fee imposed on the burning of carbon-based fuels, such as coal, oil, and gas, while CO_2 emissions mainly come from burning organic materials, such as wood and solid waste. Currently, a national carbon tax is in effect in 27 countries, including several European Union (EU) nations, Canada, Singapore, Japan, Ukraine, and Argentina. The EU Emissions Trading System is one of the best examples of a cap-and-trade system. Importers of emissions-intensive goods are required to pay a fee proportional to what producers would have been required to pay under EU carbon emission regulations[4]. Study conducted in Sweden showed that upon the implementation of the carbon tax, CO_2 remission was significantly reduced by 11% in an average year[5].

The general population in several countries will be impacted by the implementation of carbon tax, especially the poorest households because they tend to spend a larger share of their income on gas, heat, and other emissions-generating activities[6]. Hence, this systematic review will present the factors associated with carbon tax awareness among the general population.

METHODS

This systematic review was prepared in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) updated guideline. The objective of this review was to identify the factors associated with carbon tax awareness. The components of the mnemonic PEO (population, exposure, outcome) were established as follows:

- Population: general population.
- Exposure: associated factors of awareness.
- Outcome: carbon tax policy.

Search Strategy

The literature search was conducted from 1st November until 1st December 2022 using Scopus and ScienceDirect. The following keywords were used for searching related articles: “carbon tax policy” OR “carbon tax” AND “awareness” AND “factors” OR “determinants”. All retrieved articles were imported into the EndNote20 library and then, library deduplication was implemented.

Eligibility Criteria

The inclusion criteria were as follows: (1) published in the English language; and (2) original articles, which included cohorts, case–controls, and cross-sectional studies that investigated the associated factors of carbon tax awareness. In contrast, mixed methods and qualitative studies, as well as non-original articles, such as conference proceedings, perspective, commentary, opinion, reports, systematic review, and meta-analyses were excluded. The publication period was selected to include articles from 2010 and onwards.

Study Selection

First, two independent reviewers screened the titles and abstracts of the retrieved articles based on the inclusion and exclusion criteria. Potential articles identified during the main screening were kept. Second, the full texts were reviewed independently by the same reviewers according to the inclusion and exclusion criteria. The third reviewer was assigned to resolve any disagreements that arose between pairs of the previous reviewers.

Critical Appraisal and Data Extraction

The quality of the articles was appraised using the Mixed Methods Appraisal Tool (MMAT), which focused on five core methodological quality criteria for each selected article[7]. A reviewer extracted the data that were then assessed independently by a second reviewer. Eligible articles were analysed in detail using the content analysis method without any statistical tests.

RESULTS

The search yielded 26 articles from Scopus and 336 from ScienceDirect, resulting in 362 unique hits. Only two articles are included in the full-text assessment following a rigorous selection screening, as shown in the PRISMA flow diagram (Figure 1). The study locations and designs of the selected articles are presented in Table 1. The findings from these studies have been summarised in this systematic review, as shown in Table 2, with one eligible article from Canada and one from Taiwan. The analysed articles were published between 2010 and 2022 and both articles were cross-sectional studies.

Table 1. List of study locations and study designs.

Study Location	Study Design	Authors, Year
Canada	Cross-sectional	Long et al., 2020[8]
Taiwan	Cross-sectional	Dang et al., 2021[9]

Sociodemographic Characteristics

A study conducted in Canada and California examined participants aged 18 and above, with sample sizes of 1,552 for Canada and 484 for California. In Canada, 22% of participants were aged 65 or older, whereas in California, the largest age group was 35-44 years old (22%). In terms of education, 40% of Canadian participants had attained a diploma, while 33% of Californians held a bachelor's degree. The majority of participants in both regions were female, with 52% in Canada and 54% in California. Most participants lived in urban or suburban areas, accounting for 83% in Canada and 94% in California[8]. A similar study in Taiwan, which examined 450 participants aged 20 and above, revealed that 44.5% of participants were over 50 years old, with 50.4% being female. Additionally, 39.8% had completed college or university-level education[9].

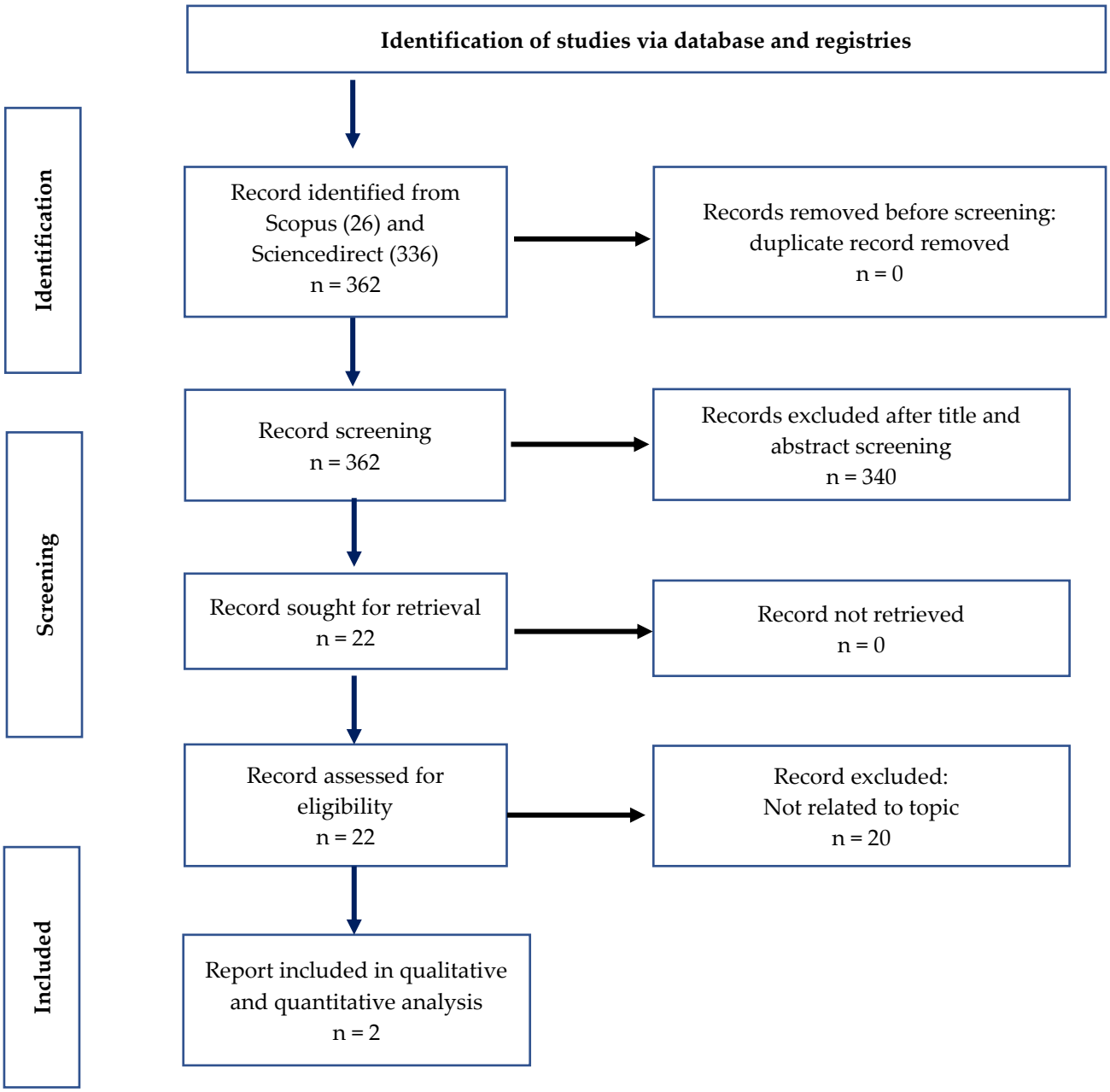

Figure 1. PRISMA flow diagram for the systematic review

Table 2. Summary of the accepted articles.

Author (Year)	Title	Study Design	Sample Size	Study Locations	Outcomes	Factors
Long et al., 2020[8]	Public support for supply-focused transport policies: Vehicle emissions, low-carbon fuels, and ZEV sales standards in Canada and California, USA	Cross-sectional	n = 2063	Canada and California, USA	Awareness, levels of support and opposition for the supply-focused and carbon tax policies among Canadian provinces, and in California, USA, including the factors that underlie support for each policy.	1. Awareness of a carbon tax for comparison, with fewer respondents in Quebec (41%) and California (25%) identifying a carbon tax as being in place, which could be partially explained by both regions having cap-and-trade systems in place (not carbon taxes). 2. Support for a strong carbon tax (CAD $150/tonne) was the lowest (and similarly low amongst regions) of all policies, with 22% to 30% of respondents supporting it. Opposition for a strong carbon tax was the highest among the policies, ranging from 42% to 65%. For a moderate carbon tax (CAD $50/tonne), 27% to 38% of the respondents stated their support, while 37% to 59% were opposed. 3. Trust in the federal government ($B = 0.831$, $p < 0.001$) 4. Climate change concern ($B = 0.524$, $p < 0.001$) 5. Environmental concern ($B = 0.293$, $p < 0.001$) 6. Education ($B = 0.258$, $p < 0.05$) 7. Age ($B = -0.009$, $p < 0.001$) 8. Annual household income ($B = 0.0294$, $p < 0.05$)
Dang et al., 2021[9]	What makes consumers willing to pay for carbon taxes: A view of terror management theory	cross-sectional study	N = 450	Taiwan	Factors associated with awareness and willingness to pay carbon tax.	1. Health consciousness (being more health conscious can and will, in turn, initiate amongst consumers a desire to contribute towards saving and preserving the environment by paying extra for CO_2 emissions ($R^2 = 0.157$; $Q^2 = 0.095$, $p < 0.05$)

Carbon tax awareness

This review has analysed two articles that focused on carbon tax awareness. Factors that facilitate carbon tax awareness were found to be sociodemographic characteristics, trust in the federal government, and environmental and climate change concerns. The studies included in this review reported the positive effects of these factors on carbon tax awareness.

Factors associated with carbon tax awareness

Sociodemographic characteristics

There was a significant relationship between education level ($B = 0.258$, $p < 0.05$), age ($B = -0.009$, $p < 0.001$), and annual household income with awareness of carbon tax policy ($B = 0.0294$, $p < 0.05$) (Long et al., 2020)[8].

Trust in federal government

There was a significant positive relationship between policy support and trust in the federal government ($B = 0.831$, $p < 0.001$). According to the study, trust in the subnational government was more important in California, USA than in the Canadian sample baseline. Trust in the California Air Resources Board (a state government actor) was viewed as an interaction term (as this variable only applied to those living in California), which was also significantly associated with support for all policies[8].

Environmental and climate change concerns and consciousness

There was a significant relationship between environmental concern and awareness of the carbon tax policy ($B = 0.293$, $p < 0.001$). A significant relationship between climate change concern and awareness of carbon tax policy ($B = 0.524$, $p < 0.001$) was also found[8]. Health consciousness, which means being more health conscious, can and will, in turn, initiate the desire amongst consumers to contribute towards saving and preserving the environment via CO_2 emissions tax ($R^2 = 0.157$; $Q^2 = 0.095$, $p < 0.05$)[9].

Risk of Bias

The methodology quality of the selected studies was appraised using the Mixed Methods Appraisal Tool (MMAT) based on five criteria[7]. Details of this assessment are reported in Table 3. The quality of the included studies has been thoroughly checked and deemed satisfactory based on several key factors. First, the sampling strategies used in the studies were assessed to ensure they were relevant to addressing the research questions, with attention to whether the samples were representative of the target populations. Additionally, the appropriateness of the measurements was carefully reviewed to confirm they aligned with the study objectives and were robust enough to capture the necessary data. Nonresponse bias was also evaluated, and efforts were made to minimize its impact, ensuring the results could be generalized more confidently. Finally, the statistical analyses employed in the studies were scrutinized to confirm they were suitable for answering the research questions and adequately supported the findings. These quality checks ensure that the studies included in the review are reliable and valid for drawing meaningful conclusions.

Table 3. Details of the MMAT assessment.

Author	Type of Study	1.1 Is the sampling strategy relevant to address the research question?	1.2 Is the sample representative of the target population?	1.3 Are the measurements appropriate?	1.4 Is the risk of nonresponse bias low?	1.5 Is the statistical analysis appropriate to answer the research question?
Long et al., 2020[8]	Quantitative descriptive	yes	yes	yes	yes	yes
Dang et al., 2021[9]	Quantitative descriptive	yes	yes	yes	yes	yes

DISCUSSION

This review has determined three categories of factors that contributed towards carbon tax awareness, namely, sociodemographic characteristics, trust in the federal government, and environmental and climate change concerns. The awareness and support among the public for a carbon tax was higher in most regions, as similarly reported by a 2013 Canadian survey[10]. Such a high level of awareness can likely be explained by the greater industry and political oppositions, as well as media coverage received by carbon taxes.

Sociodemographic characteristics
Educational levels can influence how people think and act[11]. A study was conducted among German citizens on their support for low-carbon energy policies, which similarly showed that support can be explained by characteristic factors (e.g., age, gender, education level)[12]. Generally, higher climate policy support can be associated with being younger, wealthier, and highly educated (Leiserowitz, 2006; Rhodes et al., 2014; Ziegler, 2017).

Trust in the federal government
In addition, citizens that trust their government have shown greater support for carbon taxation[10]. Another study has similarly found trust in government to be linked with greater support for carbon taxation in Sweden and Canada[13]. The public's trust in the government can also lead to stronger policy support[8].

Environmental and climate change concerns and consciousness
In general, biospheric and altruistic values, environmental concern, and climate change concern were found to be associated with greater policy support, while traditional and egoist values were associated with lower policy support. These observations were consistent with previous studies that examined support for gasoline taxes, carbon tax, and industry-focused climate policies[14,15]. Surveys conducted in the US, Canada, and Germany reported that greater environmental concern led to greater climate policy support, including for a carbon tax[10,13]. Studies in Canada and the US found that support for climate policies was associated with greater concern about climate change, including support for the carbon tax, and other supply-focused regulations[10,14]. Other study have identified health consciousness as an underlying psychological factor, whereby individuals' awareness and involvement in their health conditions can determine pro-environmental behaviours. Consequently, when consumers understand that environmental changes can threaten their health, it can motivate them to undertake pro-environmental behaviour[16].

The behaviour of individuals can play an important role in the efforts to reduce CO_2 emission and support for any measures towards this aim, for instance, carbon tax policy implementation. Health consciousness may have a positive influence on the willingness of individuals to pay extra to offset carbon emissions because of the fear of the adverse effects of environmental pollution on their health[9].

Barriers in implementing carbon regulatory policies
Economic factors carried the heaviest weight for barriers in implementing carbon regulatory policies. Economic factors, namely, lack of initial funding, hidden costs, and uncertain carbon price markets have been ranked the top three barriers that are hindering the implementation of these policies[17]. It is important to have enough funding for manufacturers to support measures to reduce carbon emission. In addition, research and development on the advantages and disadvantages of the implementation of CRPs are still lacking to provide evidence-based and reliable information to the stakeholders. Subsequently, the goal to reduce carbon emission through CRPs might be unachievable, if there is lack of support from the government and relevant authorities[17].

Effectiveness of interventions to increase carbon tax awareness
To improve public awareness and support for carbon taxation, several potential interventions and communication strategies have been employed in various regions. One notable example is the use of tax revenues from carbon pricing to fund rebates for citizens, making the policy more acceptable. This initiative was supported by a targeted public education campaign that simplified complex carbon tax concepts and framed the policy in a positive, relatable manner. Similarly, communication strategies emphasized the tangible benefits of carbon taxation, such as improved public health and air quality, which resonated strongly with the public. Both examples highlight the importance of transparent communication, aligning policy benefits with public values, and using relatable language to increase carbon tax awareness and support.

Recommendation
Based on the findings of these studies, it is important for governments to build trust among the population to bolster support for climate policy, accelerate carbon regulation, and the adoption and implementation of environmental policies. Awareness and educational programmes regarding the dangers of carbon emissions, and the importance of achieving sustainable development goals leading to a zero-carbon future can help create more support towards the implementation of these policies.

Limitation
One limitation of this review is that only two databases were used to search for articles resulting in the identification of just two relevant studies. This limited scope may hinder the comprehensiveness of the review, as it potentially overlooks key research and insights that could be found in broader, more diverse sources. Expanding the search to additional databases and including grey literature, such as reports, policy briefs, and other non-peer-reviewed sources, would enhance the review's depth and breadth. Additionally, removing restrictions on publication years would allow for the inclusion of older studies that may still provide valuable contributions to the topic.

Another limitation to consider is only English-language articles were included. While the review did source literature from several countries where English is not the primary language, the exclusion of non-English studies may have resulted in the omission of relevant findings. Language bias could have affected the generalizability of the conclusions drawn.

Additionally, the review lacks quantitative data on public awareness levels across different demographics and regions. Integrating such data would allow for a clearer understanding of how various factors influence carbon tax awareness and where targeted interventions could be most effective. Furthermore, the review does not explore long-term trends in carbon tax awareness, which would provide valuable insights into how public understanding of this issue has evolved in response to policy changes, economic conditions, and major environmental events. This kind of analysis could help identify patterns and predict future levels of public awareness, offering a more dynamic perspective on the subject.

To improve future systematic reviews, broadening the search strategy to include a wider range of databases, removing language restrictions, and incorporating grey literature would ensure a more exhaustive collection of studies, offering a comprehensive overview of the subject. Expanding the time frame to include older studies and integrating more quantitative data would provide additional context, helping to identify demographic and regional trends in awareness. Finally, conducting longitudinal analyses on public awareness levels in response to policy changes and external factors would offer deeper insights into how carbon tax awareness evolves, enabling more accurate predictions and tailored policy interventions. Despite these limitations, this review successfully synthesizes research evidence on the factors associated with carbon tax awareness and can serve as a guide for improving public awareness strategies and communication efforts.

CONCLUSION

Reducing carbon emissions has become a great concern among environmentally conscious businesses and governments around the globe. Currently, carbon taxes are regarded as some of the most cost-effective instruments to decrease CO_2 emissions. The associated factors of carbon tax awareness identified in this systematic review can be used as a guideline in designing evidence-based measures and policies. On the basis of these findings, this review offers key managerial instructions for the carbon offset programme.

Author Contributions
All authors were involved in the conceptualisation of the methodology, extensive search of articles, critical review of articles, result synthesis, and original draft write-up. All authors have read and agreed to the published version of the manuscript.

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