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# Costly myths: An analysis of idling beliefs and behavior in personal motor vehicles ☆

Amanda R. Carrico [a,*], Paul Padgett [b], Michael P. Vandenbergh [c], Jonathan Gilligan [d], Kenneth A. Wallston [e]

[a] Department of Psychology, Vanderbilt University, PMB 407817, 2301 Vanderbilt Place, Nashville, TN 37240-7818, United States
[b] Vanderbilt Center for Environmental Management Studies, Owen Graduate School of Management, 401 21st Ave South, Nashville, TN 37203, United States
[c] Vanderbilt University School of Law, 131 21st Ave South, Nashville, TN 37203, United States
[d] Department of Earth and Environmental Sciences, Vanderbilt University, 2301 Vanderbilt Place, Station B 35-1805, Nashville, TN 37235-1805, United States
[e] Vanderbilt University School of Nursing, Godchaux Hall, 461 21st Ave south, Nashville, TN 37240-7817, United States

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ABSTRACT

Despite the large contribution of individuals and households to climate change, little has been done in the US to reduce the $CO_2$ emissions attributable to this sector. Motor vehicle idling among individual private citizens is one behavior that may be amenable to large-scale policy interventions. Currently, little data are available to quantify the potential reductions in emissions that could be realized by successful policy interventions. In addition, little is known about the motivations and beliefs that underlie idling. In the fall of 2007, 1300 drivers in the US were surveyed to assess typical idling practices, beliefs and motivations. Results indicate that the average individual idled for over 16 min a day and believed that a vehicle can be idled for at least 3.6 min before it is better to turn it off. Those who held inaccurate beliefs idled, on average, over 1 min longer than the remainder of the sample. These data suggest that idling accounts for over 93 MMt of $CO_2$ and 10.6 billion gallons (40.1 billion liters) of gasoline a year, equaling 1.6% of all US emissions. Much of this idling is unnecessary and economically disadvantageous to drivers. The policy implications of these findings are discussed.



## 1. Introduction

According to the fourth assessment report of the intergovernmental panel on climate change (IPCC), the current and projected rates of greenhouse gas (GHG) emissions worldwide have created a non-trivial risk of catastrophic climate change (IPCC, 2007). To reduce this risk, a substantial reduction in global carbon dioxide ($CO_2$) emissions will be necessary. Based on the most recent estimates from the Energy Information Administration (EIA), the United States accounts for over 20% of worldwide $CO_2$ emissions and ranks just behind China as the second largest $CO_2$ producing country in the world (EIA, 2006). At the current pace, total $CO_2$ emissions from the US are projected to increase at a rate of nearly 0.5% a year between now and 2030 (EIA, 2007). The stabilization and ultimate reduction of $CO_2$ emissions within the US is, therefore, critical to international efforts to minimize the global impact of climate change. To ensure that global greenhouse gas concentrations do not exceed limits in the range of 450–500 parts per million (ppm), it has been proposed that the United States level-off its emissions at 2007 levels and reduce them by an additional 60–80% by 2050 (US Climate Action Partnership, 2007).

Within the United States, the current debate over how to manage $CO_2$ emissions has focused predominantly on the use of clean-fuel technology and the economic regulation of industry (Vandenbergh et al., 2008). Although these measures will be critical to stabilizing and reducing emissions, many have argued that the necessary reductions cannot be achieved without also reducing the emissions associated with the individual and household sector (e.g., Bin and Dowlatabadi, 2005; Vandenbergh et al., 2008). Estimates have placed the direct contribution[1] of this sector within the range of 30–40% of all US emissions, which is roughly 8% of the world total and accounts for more than any other country in the world excluding China (Bin and Dowlatabadi, 2005; Vandenbergh and Steinemann, 2007). Recent analyses have

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* Corresponding author.
*E-mail address:* amanda.carrico@gmail.com (A.R. Carrico).

[1] These estimates are based on a definition that includes direct individual and household behavior, including personal transportation (e.g., the use of personal motor vehicles, mass transit and air travel) and end-use electricity in the household (e.g., space heating, water heating, and other appliance use). Indirect influences of consumers, such as food and apparel purchases, are excluded.

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indicated that a large proportion of the emissions associated with this sector could be avoided with a number of relatively simple behavioral modifications. For example, Gardner and Stern (2008) have estimated that the individual and household sector could reduce emissions by roughly 30% in the immediate future without major economic sacrifice or loss of personal well-being by individuals and homeowners. If realized, a reduction of this magnitude would result in a 2% decline in $CO_2$ emissions worldwide.

Given the scale and urgency of the emissions reductions necessary to lower the risk of catastrophic climate change, a primary challenge for scientists and policymakers is to identify sources of emissions within the individual and household sector that have the capacity for substantial reductions if changed in large numbers, and are sufficiently malleable in response to policy interventions. York et al. (2002, 2003) have discussed the importance of considering both *elasticity* and *plasticity* of environmental drivers. Elasticity (referred to as *ecological elasticity*) describes the potential change in an environmental impact that results from a change in a driving force. Plasticity, on the other hand, refers to both the potential variability and rate of change in a target that can be expected if an intervention is instigated. When this logic is applied to the issue of behavioral sources of emissions, elasticity can be conceptualized as the level of $CO_2$ emissions associated with a given behavior, and plasticity as the capacity for producing a meaningful level of behavior change within a given time frame.

Historically, policymakers have tended to focus on behaviors that have the highest degree of elasticity, such as the use of public transportation, with little regard to the level of behavior change that can be realistically expected. However, decades of psychological research have suggested that efforts to promote voluntary behavior change will be most effective when the behavior is under the individual's perceived control, involves few situational barriers, and includes built-in incentives (or the absence of disincentives) such as financial or social rewards (e.g., Conner and Armitage, 1998; Kaiser et al., 1999; Schultz et al., 1995; Wall, 1995). With the exception of a few cities that have well-developed mass transit infrastructures, public transportation in the US tends to be inconvenient, time-consuming and, in many cases, less cost-effective than driving. Not surprisingly, efforts to promote the use of public transportation tend to be most effective when they simultaneously address issues related to access, cost and convenience (e.g., Heath and Gifford, 2002; Henry and Gordon, 2003). In a similar vein, the use of tax incentives or efficiency standards to promote the adoption of more efficient vehicles have the potential to lead to large reductions in driving-related emissions. However, the relatively slow rate at which new vehicles are purchased and the old ones retired will result in long delays before the effects of these policies are fully realized.

Both of the examples described above involve behaviors that have a high degree of elasticity but a low degree of plasticity, particularly with respect to the goal of reducing emissions in the short-term. It is clear that policies directed at these sources of emissions will be critical to the long-term success of US climate policy. However, we argue that there may also be cost-effective opportunities for reducing individual and household emissions in the short-term. In this paper, we examine one such behavior that may be considered a ''low-hanging fruit'' in the effort to reduce individual and household emissions because of its high degree of both elasticity and plasticity. As will be discussed below, there is reason to believe that personal motor vehicle idling (hereafter referred to simply as ''idling'') accounts for a non-trivial amount of $CO_2$ emissions and fuel use annually. Likewise, beliefs and motivations associated with the decision to idle one's vehicle suggest this behavior may be highly malleable with appropriate policy interventions. Although some regulation is beginning to take place in the US to target idling in personal motor vehicles, this behavior has remained largely under the radar of policymakers as a potential source of emissions reductions.[2] In the following pages we discuss why idling may be a good candidate for policy interventions. We then attempt to quantify the potential emissions reductions and savings in fuel consumption if idling were to be successfully targeted and modified by the American public. Beliefs about idling and the relation between these beliefs and actual behavior will also be examined. Finally, the policy implications of these findings, particularly the potential costs and benefits of a federal effort to reduce idling, will be discussed.

## 2. Motor vehicle idling

Idling refers to situations in which a vehicle's engine is running while the vehicle is stopped. Although there are a variety of settings in which individuals may idle a vehicle, this behavior can be broadly categorized into three domains: (1) idling to warm the engine; (2) idling while waiting for something unrelated to traffic (e.g., waiting for a passenger; in a drive-thru); and (3) idling while in traffic (e.g., at stoplights; in traffic jams). Recommendations for what is considered a desirable amount of idling have varied as vehicle technology has improved. For example, it was once considered desirable to warm a vehicle's engine before driving; however, most modern fuel-injected engines do not need warming, and restarting a vehicle uses less fuel and causes less wear and tear on the vehicle's engine than idling for 10 s or more (Taylor, 2003; Ueda et al., 2001; Matsuura et al., 2004). Consequently, both the US Environmental Protection Agency (EPA, 2004) and Natural Resources Canada (NRC, 2008) recommend idling for no more than 30–60 s.

In many cases, idling while in traffic is hard to avoid for practical and safety reasons, and delays in restarting vehicles could contribute to traffic jams. Idling in traffic is, therefore, a poor initial target for policy interventions. On the other hand, idling to warm the engine and while waiting is often unnecessary given that, in most cases, a person can turn off his or her engine or avoid situations that require idling (e.g., parking rather than using a drive-thru) without major consequences or safety concerns. Furthermore, idling in these contexts often will have net monetary costs to the individual and will offer little non-monetary benefit beyond the comfort or convenience provided by leaving the engine running.

Little data are available regarding how frequently Americans idle and for what duration of time, particularly with respect to unnecessary idling. Likewise, little is known about the reasons why individuals idle if they choose to do so. A series of studies conducted in Canada have suggested that the average individual idles anywhere from 1.4 to 4.6 min a day in situations excluding traffic. For example, in a nationwide telephone survey of Canadian residents, the average respondent reported idling for 26 min a week (3.7 min per day) to warm their engines and 13 min (1.9 min a day) while waiting in their vehicles (McKenzie-Mohr Associates, 2003). A similar survey of residents in the city of Sudbury, Ontario found that the average resident reported idling between 1.4 and 3.3 min within the past 24 h. Participants were also asked to report how long they believed a vehicle could be idled before it would use more fuel than restarting it. Only 6–9% of the

[2] This regulation has primarily been in the form of local ordinances as well as some state-level policies (EPA, 2006a). Although these efforts reflect a growing commitment among policymakers to reduce the negative effects of idling (e.g., pollution, noise, $CO_2$ emissions), they tend to be difficult to enforce and do little to educate individuals as to why idling is discouraged.

participants held accurate beliefs, and the average participant believed a vehicle could be idled for more than three minutes before it becomes more efficient to turn it off. The same authors observed idling behavior in various parking lots (e.g., schools, malls, grocery stores) around the city. They discovered that, among those waiting in their vehicles, 50–55% idled. Those that did so idled for over three minutes before driving or turning the vehicle off (McKenszie-Mohr Associates, 2003).

These findings provide evidence that individuals commonly engage in unnecessary idling and that this may be, in part, due to misinformation about what is beneficial for oneself and the environment. However, the extent to which these estimates are relevant to the US population is unclear. These data were collected in Canada where temperatures frequently dip below freezing and idling practices may be more common because of this. On the other hand, there has been a greater documented effort to educate individuals about idling in Canada and, as a result, these data may represent an underestimate of Americans' idling practices due to a lack of knowledge and awareness about this issue. We currently know of no large-scale survey of the American public about their idling practices, beliefs and motivations. The research described below is a first attempt to do this in an effort to quantify the emissions and fuel use associated with idling, as well as to assess general knowledge and beliefs about this issue.

## 3. Methodology

### 3.1. Participants

Participants were 1300 US residents recruited during the fall of 2007 from an online research panel.[3] All participants were 18 years or older at the time the survey was completed and reported that they owned or had access to a private vehicle. The average respondent was 43 years old and reported having completed "some college" and earning between US$50,000 and US$75,000 a year. Table 1 summarizes the demographic profile of the present sample as compared to that of the larger US population. With the exception of age, the sample matched closely with the demographic profile of the 2000 US Census data as well as the 2007 population data for region (US Census Bureau, 2000, 2007). Although not fully representative, this sample is considered to be a reasonably good estimate of the population for the purpose of this analysis.

### 3.2. Procedure

This survey was conducted during the fall of 2007. Prospective participants were invited via e-mail to enroll in survey about motor vehicle idling. Those who agreed to participate were directed to a website where they were asked to report their idling behavior during the 24 h prior to taking the survey. Items were broken down according to whether the idling occurred while warming a vehicle (warming), while waiting in situations other than traffic (waiting), or while sitting in traffic (traffic). In each section, participants also indicated the extent to which a number of factors (e.g., time, money, gas, convenience) influenced their decision to idle or not. This series of items was followed by an additional set of questions regarding the individual's beliefs about how much idling is desirable in various contexts. The items used in this survey can be found in Appendix A.

[3] All participants were recruited from the online research panel eLab, managed by Vanderbilt University's Owen Graduate School of Management (http://eLaboratoryvanderbilt.edu/). The panel includes over 50,000 internet users who have volunteered to participate in behavioral projects.

**Table 1**
Demographic profile of sample and population.

| | Sample | Population[a] |
|---|---|---|
| Sex (% female) | 54 | 51 |
| Age (median) | 43 | 35 |
| Education (median) | Some college | Some college |
| Income (median) | $50,000–$74,999 | $50,000 |
| Region[b] | | |
| Northeast | 20% | 18% |
| Midwest | 23% | 22% |
| South | 39% | 37% |
| West | 17% | 23% |

[a] Based on 2000 US census data.
[b] Based on 2007 population data.

### 3.3. Measures

*Demographics*: participants were asked to report their sex, age, education and income. Level of education was reported using one of five responses—"some high school or less", "high school", "some college", "college graduate", and "professional or graduate degree". Annual income from the previous year was reported on a five-point scale ranging from "less than $15,000" to "75,000 or more".

*Idling behavior*: the items and calculations used to estimate each of the three idling behaviors (warming, waiting and in traffic) are described below. Large variances were observed for all estimates. This was, in part, due to the influence of outliers in the sample. So as not to overestimate idling times, those individuals who scored more than three standard deviations above the mean on any one of the items used to calculate idling times were excluded from that estimate. This led to very slight changes in the final estimates and had no effect on the overall interpretation of these data.

Idling to warm was estimated by multiplying the number of times an individual started his or her engine within the 24 h prior to the survey (mean [$M$] = 4.2, standard deviation [$SD$] = 2.7) by the average amount of time that individual idled his or her vehicle each time the engine was started ($M = 1.2$; $SD = 1.7$). The average respondent reported idling to warm for 4.2 min a day ($SD = 5.5$).

Idling while waiting in situations other than traffic was based on the number of instances an individual reported waiting in his or her vehicle ($M = 1.3$, $SD = 2.0$) multiplied by the average amount time he or she idled while waiting ($M = 1.8$ min, $SD = 2.6$). This produced an average of 3.7 min of idling a day ($SD = 6.2$).

Idling while in traffic was defined as the amount of time a respondent was stopped in traffic (i.e., stop lights, traffic jams, etc.) with the engine on ($M = 9.9$, $SD = 11.2$) minus the amount of time he or she waited with the engine turned off ($M = .4$, $SD = 2.2$). Only 9% of the sample reported turning off their engines while waiting in traffic. The average respondent idled in traffic for 8.2 min ($SD = 7.8$) within a 24-h period.

*Beliefs about idling*: general beliefs about the effects of idling were measured with four items. Participants were asked to report how long they should idle before restarting their vehicle in order to: "save gas", "reduce air pollution", "save money", and "prevent vehicle wear and tear". Participants indicated their response in minutes (ranging from "0" to "60 or more") and seconds ("0" to "59") using two drop-down menus.

To measure beliefs specifically about idling to warm an engine, participants were asked to report how long a vehicle should be idled before driving in the following five temperature conditions:

**Table 2**
Summary of $CO_2$ emissions and fuel consumption associated with idling behavior.

| | min/day | $CO_2$ emissions | | Fuel consumption | |
|---|---|---|---|---|---|
| | | Annual per person emissions (pounds/kg) | Annual US emissions (MMt) | Annual per person consumption (gallons/l) | Annual US consumption in billions (gallons/l) |
| Warming | 4.2 | 283.9/128.8 | 24.5 | 14.6/55.3 | 2.8/10.6 |
| Waiting | 3.7 | 250.1/113.4 | 21.6 | 12.8/48.5 | 2.4/9.1 |
| Traffic | 8.2 | 554.3/251.4 | 47.8 | 28.4/107.5 | 5.4/20.4 |
| Total | 16.1 | 1088.3/493.6 | 93.9 | 55.8/211.2 | 10.6/40.1 |

"cold weather (less than 32 °F)," "cool weather (between 33 and 54 °F)," "mild weather (between 55 and 70 °F)," "warm weather (between 70 and 90 °F)" and "hot weather (more than 90 °F)."

## 4. Results and discussion

### 4.1. Idling behavior

Table 2 provides summary data for the amount of time the average respondent reported idling in each of the three contexts, as well as the level of emissions and fuel use associated with these behaviors. To allow for an estimation of Americans' idling behavior within any given 24 h period, these analyses include individuals who reported that they used their vehicle but did not idle as well as those who did not start their vehicle within the 24 h prior to the survey. No differences in any of the three idling categories were found across the days of the week; therefore, the average 24-h estimate was multiplied by 365 to calculate yearly idling emissions. These values were multiplied by the 190 million Americans who own one or more vehicles to produce estimates for the US population (Nielsen Company, 2007). The $CO_2$ emissions estimates were based on data provided by Frey et al. (2003) which, when averaged, suggest that the average idling vehicle emits roughly 1.4 g of $CO_2$ per second. Fuel consumption was based on the estimate that the average vehicle uses .57 gallons (2.16 l) of fuel per hour of use[4] (EPA, 2005).

Based on these calculations, the average American idles for roughly 16 min a day, resulting in close to 94 MMt of $CO_2$ and over 10 billion gallons (40 billion liters) of gasoline annually. The $CO_2$ emissions associated with idling accounts for roughly 1.6% of the total US emissions, based on estimates from 2006 (EIA, 2006). To put these figures into context, 94 million tons of $CO_2$ is almost double the total emissions for the iron and steel manufacturing industry which, as the largest industrial source of carbon in the US, produces around 51 million tons annually (EPA, 2006b). Likewise, based on Vandenbergh and Steinemann (2007) calculations, idling accounts for nearly 9% of all $CO_2$ emissions associated with the use of private motor vehicles and 5% of all emissions attributable to the individual and household sector.[5] It should be noted that these estimates are within the range of other estimates, although slightly higher, which conclude that 5–8% of fuel use in personal motor vehicles is due to idling (e.g. Vandenbergh et al., 2008; Taylor, 2003).

Over 51% of these estimates can be accounted for by individuals idling while in traffic, which may be largely outside of one's direct behavioral control. However, the remaining 49%, comprising of 46.1 MMt of $CO_2$, results from idling to warm and while waiting, both of which are avoidable and, in many cases, unnecessary.

### 4.2. Potential emissions reductions

To reduce pollution, vehicle wear and tear, and fuel consumption, the EPA suggests idling for no more than 30 s (EPA, 2004). The estimates presented above suggest that there is a potential for large reductions in $CO_2$ emissions if individuals in the US were to conform to this recommendation. For the purpose of estimating potential savings in fuel and emissions, the 30-s standard was used as the benchmark for compliance per idling event. Because the decision to idle in traffic is affected by a number of factors external to the individual, including safety, concerns over holding up traffic, etc., only the emissions associated with idling to warm and while waiting were considered in this analysis.

Roughly 48% ($n = 625$) of respondents in the present sample reported idling their vehicles for more than 30 s to warm their engine, and 46% ($n = 598$) reported leaving their engine on for longer than 30 s while waiting.[6] By subtracting 30 s from the average amount of time these individuals idled to warm and while waiting, and then multiplying that number by the number of idling events for each respondent, we can calculate the amount of time each individual within these groups engaged in unnecessary idling. These estimates, along with their associated $CO_2$ emissions and fuel consumption, are presented in Table 3. To estimate the annual emissions associated with this behavior nationwide, the annual per person $CO_2$ emissions and gallons of fuel consumption were multiplied by the 91.2 million Americans who are estimated to warm their vehicles for more than 30 s on any given day, as well as the 87.4 million who idle outside of traffic daily.

These calculations indicate that if Americans were to reduce their idling to what is recommended by the EPA, roughly 15.8 MMt tons of $CO_2$ would be removed from the atmosphere annually, which equals nearly 0.3% of the all US emissions (EIA, 2007). This is roughly equivalent to the emissions associated with the entire ammonia industry, which emits 16.9 million tons a year (EPA, 2006b). It is also larger than the emissions from the soda ash, aluminum and limestone industries *combined* (these industries emit 4.2, 4.3 and 6.7 million tons of $CO_2$ a year, respectively). Furthermore, this would reduce fuel consumption in the US by

[4] This figure is based on the estimate reported by the EPA (2005) that the average vehicle emits roughly 19.4 pounds of $CO_2$ per gallon of gasoline. Based on Frey et al.'s (2003) estimate that an idling vehicle emits 1.4 g of $CO_2$ per second, 19.4 pounds would require 1.75 h of idling at a rate of .57 gallons of fuel per hour.

[5] Vandenbergh and Steinemann (2007) estimate 7869 pounds of $CO_2$ per person for personal motor vehicle travel which, when multiplied by US population during the time these data were collected, is equivalent to 1003 MMt. They also estimate 4.1 trillion pounds, or 1852 MMt, of $CO_2$ for the entire individual and household sector. Our estimate of 94 MMt associated with idling is, therefore, equivalent to 9% of the emissions associated with personal motor vehicle use and 5% of all emissions for this sector.

[6] These figures include individuals who reported that they did not start their vehicles or wait in their vehicles during the previous 24 h. Among those individuals who did start their vehicles, 51% idled for longer than 30 s. Among those who reported waiting in their vehicles one or more times in situations other than traffic, 92% reported idling for longer than 30 s.

**Table 3**
Estimated $CO_2$ emissions and fuel use associated with unnecessary idling in the United States.

| | min/day | % of population | $CO_2$ emissions | | Fuel consumption | |
|---|---|---|---|---|---|---|
| | | | Daily US emissions (million lbs/kg) | Annual US emissions (MMt) | Daily US consumption (million gallons/l) | Annual US consumption (billion gallons/l) |
| Warming | 2.7 | 48% (91.2 million) | 45.6/20.7 | 7.5 | 2.3/8.7 | 0.9/3.4 |
| Waiting | 3.1 | 46% (87.4 million) | 50.2/22.8 | 8.3 | 2.6/9.8 | 0.9/3.4 |
| Total | | | 95.8/43.5 | 15.8 | 4.9/18.5 | 1.8/6.8 |

close to 1.8 billion gallons (6.8 billion liters) a year, saving Americans nearly $5.9 billion annually based on the average cost of fuel in 2008.[7]

### 4.3. Beliefs about idling

Presented in the top portion of Table 4 are the means and standard deviations associated with beliefs about idling durations with respect to gas consumption, air pollution, money and preventing vehicle wear and tear. Over 80% of the sample reported that it is more beneficial to let a vehicle idle for over 30 s than to turn it off and restart it (percentages for each of the four items ranged from 80% to 87%). A summary of the mean responses for these items is provided in the top portion of Table 4. These values indicate that beliefs about how much idling is appropriate or desirable are highly distorted. The average respondent believed it is better to idle for over three and a half minutes than to turn a vehicle off and re-start it when it is time to move. Beliefs regarding idling to reduce vehicle wear and tear were particularly exaggerated, perhaps reflecting outdated information that turning a vehicle off and on again is harder on the engine than allowing it to idle.

The bottom portion of Table 4 summarizes average beliefs about how long a vehicle should be warmed in various temperature conditions. Overall, participants believed a vehicle should be warmed for at least 1.8 min before driving; however, these beliefs were clearly linked to weather conditions. During cold weather, the average respondent reported that a vehicle should be warmed for 5 min; for cool weather this estimate fell to 3.5 min. Although respondents believed vehicles need to be warmed less during mild, warm or hot weather, these perceptions were still well above the 30-s standard recommended by the EPA.

**Table 4**
Beliefs about how long a vehicle should be idled.

| | *M* | *SD* |
|---|---|---|
| Before turning it off and restarting | | |
| To save gas | 4.68 | 4.23 |
| To reduce air pollution | 3.55 | 3.81 |
| To save money | 4.07 | 4.12 |
| To prevent vehicle wear and tear | 5.71 | 5.95 |
| To warm the engine during | | |
| Cold weather ($<32\,^{\circ}$F) | 5.01 | 4.48 |
| Cool weather (33–54 °F) | 3.49 | 3.87 |
| Mild weather (55–70 °F) | 1.99 | 2.79 |
| Warm weather (70–90 °F) | 1.73 | 2.54 |
| Hot weather ($>90\,^{\circ}$F) | 1.81 | 2.73 |

### 4.4. Predictors of idling

The survey results enable an examination of the demographic correlates of idling, as well as the role of beliefs and motivations. First, the correlations between four demographic variables (sex, age, education, and income) and each of the three idling behaviors were examined. In this case, only those who drove during the past 24 h were included in the analyses for idling to warm and in traffic ($n = 1226$), and only those who reported waiting in their vehicle were included in the analyses for idling while waiting ($n = 652$). It is important to note that in a sample of this size even very small and otherwise negligible correlations will often achieve levels of statistical significance. According to Cohen's (1992) guidelines for interpreting effect sizes in the social sciences, a correlation value of $r = .1$ represents a small effect size, $r = .3$ is a medium effect size, and $r = .5$ or greater is considered large. So as not to confound statistical significance with substantive significance, only those correlations that are greater or equal to $r = .1$ were flagged and interpreted.

The results of this analysis indicated that those who are more educated tend to warm their vehicles less than their less educated counterparts ($r = -.17$, $p < .01$). Likewise, older individuals reported idling less while in traffic than those who are younger ($r = -.16$, $p < .01$). However, it should be noted that idling in traffic is also confounded with how much an individual drives, while idling to warm and while waiting are not. Therefore, it is unclear whether older individuals actually idle less in traffic, or if they simply drive less overall. No effects were found for the participant's sex or level of income. Potential differences across geographic regions were also explored, although no significant effects of region were found for any of the three idling domains.

Next, a series of bivariate correlations were conducted to assess the relation between beliefs about idling and actual idling behavior. Because this study was conducted in the fall, only participants' beliefs about warming an engine during mild weather were included. The remaining items from this set (i.e., beliefs about warming during cold, cool, warm and hot weather) were excluded from this analysis. These results, presented in Table 5, provide support for the expectation that the levels of idling observed in this study are, to some extent, due to outdated beliefs about how much idling is appropriate. The more that an individual believed that idling reduces vehicle wear and tear, pollution, and saves gas and money, the more he or she reported idling in all three contexts. As expected, beliefs about idling to warm an engine were most strongly related to warming behavior, while beliefs about idling before restarting a vehicle were most closely related to idling while waiting. Together these data suggest that idling, particularly idling to warm the vehicle and while waiting, may be malleable with a properly

[7] The average cost of fuel nationwide in 2008 was $3.30. This includes all grades and formulations, and is based on weekly price averages from the first week of January 2008 to the last week of December 2008. This is based on data provided by the Energy Information Administration found here: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html.

implemented public education campaign designed to dispel outdated information.

To further explore the potential benefits of an education campaign, the behavior of those who held accurate beliefs about idling were compared to those whose beliefs were outdated. This analysis was conducted only for idling to warm and idling while waiting. Results, presented in Fig. 1, suggest that those who held outdated beliefs idled their vehicles over one minute longer both to warm their engines and while waiting. To quantify this finding, a one-minute decline in idling among the estimated 57% of Americans who hold inaccurate beliefs about warming an engine and the 80% who hold inaccurate beliefs about restarting a vehicle would reduce $CO_2$ emissions by roughly 8 million tons annually, eliminate the need for 903 million gallons (3.4 billion liters) of gasoline per year, and would save $3 billion per year at 2008 gasoline prices. Relative to the short-term goals of stabilizing $CO_2$ emissions at 2007 levels, a successful public information campaign by this would account for 27% of the average annual growth of emissions projected between now and 2012,[7] bringing us nearly one-third of the way closer to achieving this target.

**Table 5**
Bivariate correlations between beliefs about idling and self-reported idling behavior.

| | Warming ($n = 1226$) | Waiting ($n = 652$) | Traffic ($n = 1226$) |
|---|---|---|---|
| How long should a vehicle be warmed during mild weather to reduce wear and tear. | .31** | .20** | .05 |
| How long should you let your vehicle idle before restarting in order to | | | |
| Save gas | .13** | .26** | .11** |
| Reduce pollution | .17** | .26** | .13** |
| Save money | .13** | .22** | .17** |
| Reduce vehicle wear and tear | .12** | .21** | .14** |

** $p < .01$.

## 5. Conclusions

The data presented above provide compelling evidence for the claim that motor vehicle idling is a behavior worthy of policy-makers' attention. First, these data suggest that idling accounts for a substantial portion of $CO_2$ emissions and fuel consumption each year. On average, respondents reported idling for a total of 16.1 min a day, accounting for approximately 94 MMt of $CO_2$ annually and over 10 billion gallons (40 billion liters) of fuel. Furthermore, a large proportion of this total constitutes idling that is both unnecessary and economically disadvantageous for the driver. Roughly 48% of all drivers in this sample reported warming their vehicle for longer than the 30 s recommended by the EPA, and 46% idled for longer than 30 s while waiting outside of traffic, resulting in close to 16 million tons of $CO_2$ and 1.8 billion gallons (6.8 billion liters) of fuel per year.

Despite the large proportion of Americans who engage in unnecessary idling, the results presented here are somewhat promising. An analysis of respondents' self-reported beliefs and motivations surrounding idling suggests that a major factor in an individual's decision to idle is inaccurate or outdated beliefs. When asked, at least 80% of respondents reported that it is better to let a vehicle idle for more than 30 s than to turn it off and restart it again later. This was true within the context of saving gas, money, reducing air pollution, and preventing vehicle wear and tear. Likewise, the average respondent believed a vehicle should be idled for at least 2 min before driving during mild weather and even longer when the weather is cool or cold. These inaccurate beliefs were, in turn, related to an individual's decision to idle his or her vehicle for longer amounts of time. The implication of this finding is that a relatively simple but large-scale public information campaign that targets outdated beliefs has the potential to considerably reduce unnecessary idling, leading to a substantial reduction in $CO_2$ emissions in a relatively short period of time. Based on these estimates, a successful

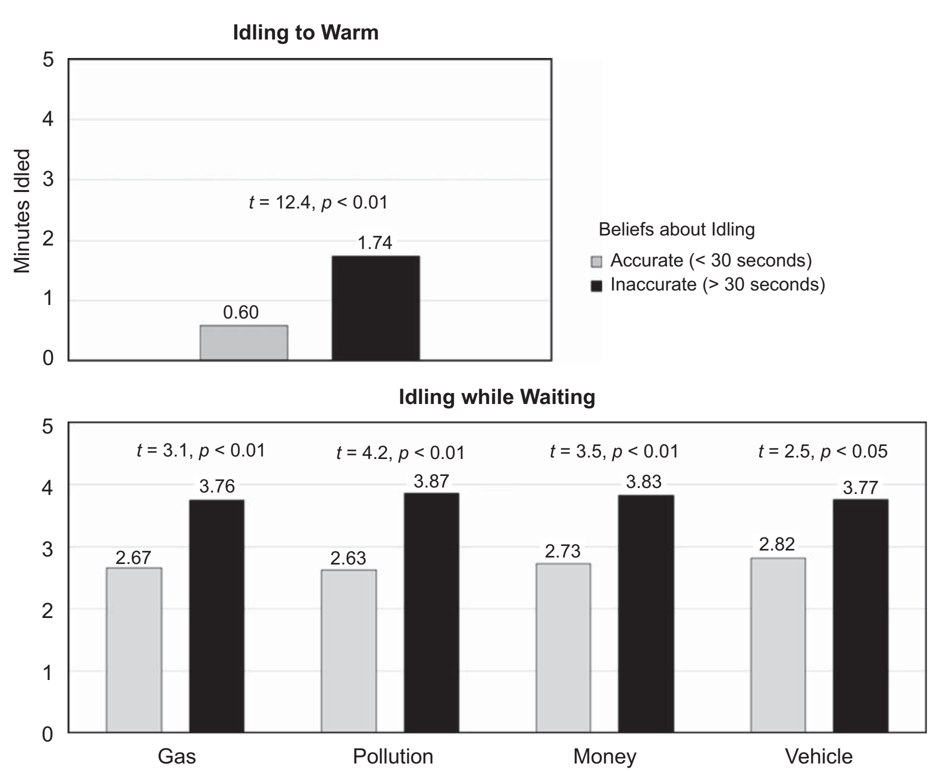


**Fig. 1.** Idling behavior as a function of beliefs about idling.

campaign that reduced unnecessary idling nationwide by an average of one minute would eliminate 8 MMt of $CO_2$ a year, accounting for 27% of the average annual growth in emissions expected between now and 2012.[8]

Previous attempts to address vehicle idling through public education have had some success. For example, a campaign targeting idling in school parking lots in one Canadian suburb resulted in a 34% decline in the number of vehicles observed idling while waiting, and a decrease in the average amount of time spent idling from 3.7 to 2.5 min (McKenszie-Mohr Associates, 2003). A similar campaign in the city of Mississauga, Canada reduced the mean duration of idling among residents from 8 to 3.5 min (Lura Consulting, 2002). To put these results in perspective, a nation-wide campaign in the U.S that achieved similar results (i.e., a reduction in mean idling times ranging from 1.2 to 4.5 min) would prevent between 7 and 26 million tons of $CO_2$ from entering the atmosphere each year, and reduce fuel consumption by 660 million to 2.3 billion gallons (2.5–8.7 billion liters) a year. Even the low end of this estimate would be the equivalent of eliminating emission from the entire limestone industry in the US, or any number of small and developing countries such as Cameroon, El Salvador and the Ivory Coast (World Resources Institute, 2009). Furthermore, the cost of implementing the latter of these two campaigns was roughly US$51,000 for a city of 625,000 residents. Based on the estimated level $CO_2$ emissions reductions achieved by this campaign, these efforts cost the city of Mississauga roughly US$0.64 per ton of carbon saved (as cited in Vandenbergh et al., 2008).[9] By comparison, today's leading legislation to reduce $CO_2$ emissions, the Lieberman–Warner Bill, is estimated to carry a national economic cost of $16–20 per ton of carbon saved by 2015 (Murray and Ross, 2007).

Although the use of anti-idling laws is difficult to enforce, there is some evidence that these regulatory measures reinforce and even strengthen the effectiveness of public education campaigns. These findings are based on a series of case studies in ten Canadian cities that implemented public education campaigns, anti-idling regulation, or both (LURA Consulting, 2005). The authors concluded that the presence of regulation legitimized public education efforts, reduced public resistance to ordinances, as well as attracted media attention to the problem. To date, no quantitative studies have been performed to examine this issue more rigorously.

Although policies focused on reducing unnecessary idling through public education may be the most effective strategy in the short-term, these results also highlight the need for technological advancement. Roughly 51% of all idling occurs while the individual is in traffic, which is often outside of the individual's direct behavioral control. This portion of idling behavior alone accounts for 47.6 million tons of $CO_2$ annually. Likewise, competing motives such as a desire to maintain a comfortable temperature in one's vehicle or to run electrical equipment without draining the battery may lead an individual to idle when it is otherwise unnecessary. Recent technologies, such as hybrid vehicles, have offered solutions for reducing this portion of emissions. However, the cost of purchasing a hybrid, along with the relatively slow rate at which individuals acquire new vehicles, limits its effectiveness in achieving emissions reductions in the short-term. On the other hand, newer devices such as integrated starter-generators (also referred to as micro-hybrid powertrains) function to shut down an engine when it comes to a stop and automatically start it again when the driver presses the accelerator (accessories such as air conditioning are re-configured to run off of an electric motor). These can be incorporated into most modern fuel-injected engines and range in price from $210 to $350 (Alson et al., 2005). Subsidies or legal requirements to promote the use of this technology, combined with a large-scale public education effort, has the potential to greatly reduce emissions associated with idling in traffic in addition to unnecessary idling.

[8] Based on calculations by the Energy Information Administration (2007), total $CO_2$ produced by the US is expected to increase at a rate of 0.5% a year between now and 2030. This is equivalent about 29.7 MMt a year between now and 2010.

[9] As reported in Vandenbergh et al. (2008), US$51,000 was spent for a city of 625,000 to reduce $CO_2$ emissions by 80,000 t. This is the equivalent cost of US$0.64 per ton of $CO_2$ saved.

## 6. Assumptions and limitations

The data presented here are a first step towards measuring idling behavior and quantifying the emissions and fuel use associated with that behavior. Multiple limitations in this work should be addressed in future studies. First, the methods used here relied exclusively on self-reported behavior, which involves a number of inherent flaws. Although many of the estimates of idling behavior reported here were similar to those found using behavioral observation techniques (e.g. McKenszie-Mohr Associates, 2003), it is possible that individuals in this sample misreported or failed to remember their actual behavior. Likewise, although it was a close approximation of the American population, this sample is not totally representative. Further research is needed to replicate and confirm these results.

In additional, this research did not fully take into account the role of weather in an individual's idling behavior. To limit response bias and inaccuracies due to memory failure, participants were asked to report their idling behavior during the past 24 h. This study was conducted in the fall, between mid-September and early October of 2007, which typically brings mild temperatures. Because individuals tend to idle more during cold or hot weather, it is likely that the results presented above have underestimated the amount of idling behavior Additional surveys or observations will be needed to replicate or update the estimates presented here.

Finally, because this study involved correlational data, no conclusive statements can be made regarding cause and effect. Based on earlier research on the effect of information on idling behavior, we have reason to believe that misinformation is a primary cause of unnecessary idling. Additional research using a controlled-experimental design would be necessary, however, to accurately test the cause and effect relationship that is hypothesized here. Given the scale and importance of this issue, further studies on this topic are highly encouraged.

## Appendix A. : Survey items

### A.1. *Idling behavior*

For each of the following items, respondents were asked to think back to the past 24 h.

#### A.1.1. *Warming*

How many times did you start your engine?

On average, how long did you idle in order to warm-up the engine each time you started your vehicle?

#### A.1.2. *Waiting*

How many times did you idle your vehicle while waiting for something unrelated to traffic; for example, waiting for a passenger or in a drive-thru (exclude situations when you idled to warm your vehicle)?

On average, how long did you idle your vehicle each of these times?

*A.1.3. Traffic*

Thinking back to the past 24 h, what is the total amount of time you spent sitting in traffic or waiting for stoplights?

How much of this time were you waiting with your vehicle turned off?

## A.2. Beliefs about idling

If I want to save gas, I should stop idling after ___ and restart the vehicle when I am ready to move.

If I want to reduce air pollution, I should stop idling after ___ and restart the vehicle when I am ready to move.

If I want to save money, I should stop idling after ___ and restart the vehicle when I am ready to move.

If I want to prevent wear and tear on my vehicle, I should stop idling after ___ and restart the vehicle when I am ready to move.

To reduce wear and tear on your vehicle, how long should you warm your engine before driving during the following weather conditions:

Cold weather (less than 32 °F)? ___
Cool weather (between 33 and 54 °F)? ___
Mild weather (between 55 and 70 °F)? ___
Warm weather (between 70 and 90 °F)? ___
Hot weather (more than 90 °F)? ___

## A.3. Motivations for idling

The same set of items was administered with respect to idling to warm, while waiting, and in traffic.

To what extent would you attribute your behavior in these situations to (responses made on a 9-point scale ranging from "not at all" to "very much".

Convenience
Desire to save time
Desire to save money
Desire to save gas
Desire to prevent pollution
Desire to reduce vehicle wear and tear
Temperature/comfort
Habit
Desire to avoid holding up traffic[10]
Other ___________

[10] Used only in reference to idling while in traffic.

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