Adolescent awareness and use of electronic cigarettes: A review of emerging trends and findings

Abstract

Adult electronic cigarette use is increasing globally and early studies have suggested that similar trends may be observed among the adolescent population, albeit at lower levels. The current literature review presents data collected since 2014 from 21 cross-sectional studies and one cohort study that were all published in English. In particular, it focuses on awareness, ever-use, past 30 day use and regular use of e-cigarettes. The article suggests that adolescents are nearing complete awareness of e-cigarettes. Furthermore, in relation to ever-use and past 30 day use, higher prevalence rates continue to be reported across time, especially in the US. Nonetheless, reported regular use of e-cigarettes remains much lower than past 30 day use, although conclusions are limited due to inconsistencies with measurement and consequent lack of cross-cultural applicability. The majority of studies do not report whether adolescents use non-nicotine electronic cigarettes. There is a current absence of longitudinal studies that explore any association between electronic cigarettes and tobacco use, and little qualitative data that may illuminate how and why adolescents use electronic cigarettes. Through addressing these methodological limitations, future research will be able to inform healthcare and policy more effectively.

Keywords: electronic cigarettes, e-cigarettes, vaping, nicotine, adolescents

Implications and Contribution

This article provides a rapid review of upwards trends in adolescent awareness and use of e-cigarettes. Current research priorities include surveying the extent of non-nicotine e-cigarette use and establishing the direction of any associations between e-cigarette and tobacco use longitudinally. Health practitioner priorities include promoting education strategies regarding what e-cigarettes are and their possible health implications.

Introduction

Electronic cigarettes (e-cigarettes; also known as electronic nicotine delivery systems or electronic vaporising devices) are battery-operated handheld devices that deliver nicotine vapour to the user. Since their introduction to the Chinese market in 2004, e-cigarettes have grown in popularity worldwide. In the UK, adult e-cigarette use has more than tripled from 700,000 users in 2012 to 2.6 million users in 2015[1]. Likewise, adult e-cigarette use in the US grew from 1.8% to 13.0% between 2010 and 2013[2]. Evidence suggests that e-cigarette vapour contains some toxic substances albeit at much lower levels than in tobacco cigarettes[3] and they may have the same efficacy as currently recommended smoking cessation medications (e.g. nicotine replacement therapies)[4 5 6]. However, there is continued debate around the potential harm and efficacy of e-cigarettes[7] and the Cochrane review of this area is clear about the need for more robust evidence, prior to making definitive recommendations[3].

Concerns regarding adolescent e-cigarette use stem from studies examining the effects of nicotine on the adolescent brain have primarily been carried out on rodents, although some studies have used human subjects[8 9 10]. These studies suggest that nicotine use may potentially

have deleterious effects. Relative to tobacco smoking, there are substantially lower health risks associated with nicotine consumption (e.g. through nicotine replacement therapies)[11]. Nonetheless, it is conceivable that use of nicotine delivered through e-cigarettes may be associated with a spectrum of adolescent risk taking behaviours, such as tobacco use or substance misuse. For an in-depth discussion of e-cigarette constituents, associated health risks and adolescent healthcare practitioner advice, please see Hildick-Smith, Pesko, Shearer et al.'s review[12].

In a previous review of adolescent e-cigarette use, Durmowicz presented data collected from 14 studies published between 2011 and January 2014[13]. The studies were carried out in France, Hungary, Lithuania, South Korea, Poland and the US. According to the review, adolescent awareness of e-cigarettes across this time period and within these countries ranged from 10.2% to 67%. Adolescent ever-use of e-cigarettes ranged from 0.5% to 23.5%, while adolescent past 30 day use of e-cigarettes ranged from 0.6% to 13%. Durmowicz emphasises the increased prevalence rates across time, in particular citing a study that suggests that e-cigarette ever and past 30 day use in US adolescents doubled between 2011 and 2012. Likewise, Chapman and Wu's similar review[14] covered the same studies as Durmowicz and therefore presented similar data. Both of these reviews are limited by the relatively low number of studies reporting awareness and use rates.

While both of these reviews were comprehensive in their scope when published, e-cigarettes are a rapidly developing product, the use of which among adults is rising and becoming more ubiquitous[1]. In addition, their safety and efficacy as smoking cessation devices continues to be widely discussed, both in the academic literature and mainstream media. The circulation of moral and medical discourse is likely to affect potential users' decisions on whether to

ultimately use e-cigarettes, as well as adolescent awareness and use patterns. As such, we feel that it is important to maintain an up-to-date review of the literature specifically focused on adolescent e-cigarette awareness and use. In the current literature review we aim to explore new trends of awareness and use among adolescents, as well as to identify any novel findings. In doing so, we aim to highlight limitations of current studies and make recommendations for future research.

Method

For the period January 2014 to January 2016, we undertook a rapid review by searching three reference databases (PubMed, Scopus, EBSCOhost) with keywords relevant to the review (see Figure 1). For example, we searched for "electronic cigarette", "e-cigarette", "electronic nicotine delivery system", "electronic vaporising device", "vaping", "adolescent", "child", "teen" and "youth", and used Boolean Operators to refine our search. In order to be considered for inclusion, articles had to be: (i) peer-reviewed journal articles; (ii) published in English; (iii) published during the period January 2014 to January 2016; (iv) about the awareness and/or use of e-cigarettes; and (v) partly or exclusively about children (i.e. people aged 18 years old or younger). If studies surveyed children at schools where the leaving age was 19 years old (e.g. in some Canadian provinces), they were included. If studies were published online ahead of print in 2016, they were also included. If studies were published during 2014, but had already been included in the aforementioned review[12], they were excluded. Finally, if studies dealt with both children and adults, but did not differentiate between the two in their results, they were excluded. Once we had identified relevant studies that met the inclusion criteria, we searched their reference lists for any further studies that also fulfilled the inclusion criteria.

Measuring e-cigarette use: terminology and clarifications

The terminology used to define e-cigarette use differs across the reviewed studies (see Table 1). The majority of studies report e-cigarette use that has either occurred "at least once" and/or "in the past 30 days". We describe these definitions under the terms "ever-use" and "past 30 day use" respectively. In addition, a small number of studies report on "frequency" of e-cigarette use, rather than use that has occurred "in the past 30 days". We describe these definitions under the term "regular use".

Results

22 relevant studies met the inclusion criteria (see Table 2). The findings of these studies can be divided into four categories: (i) awareness of e-cigarettes; (ii) ever-use of e-cigarettes; (iii) past 30 day use of e-cigarettes; and (iv) regular use of e-cigarettes.

Awareness of e-cigarettes

Seven studies[15-21] reported on the awareness of e-cigarettes among adolescents. Awareness of e-cigarettes was reported at 50.3%, 77.3% and 90.1% in the US[15 18 19]. It was reported at 76.6% in Canada, 83.2%, in the UK, 85.3% in Finland and 89.6% in Ireland[16 17 20 21].

Use of e-cigarettes

All of the studies reported on the use of e-cigarettes among adolescents. 17 studies reported ever-use of e-cigarettes, 11 studies reported past 30 day use of e-cigarettes and four studies reported regular use of e-cigarettes.

Ever-use was generally defined as previous use of an e-cigarette on at least one occasion (see Table 1). Ever-use of e-cigarettes ranged from 6.5% to 31% in the US[15 18 19 22-27]. In the UK, ever-use was reported at 8.2% and 12.3%[17 31] It was reported at 4.7% in Germany[28], 14.6% in Canada[16], 16.6% in Greece[35], 17.4% in Finland[17], 20.0% in New Zealand[29], 24.0% in Ireland[21] and 38.5% in Romania[30].

Past 30 day use was generally defined as use of an e-cigarette at least once in the past 30 days (see Table 1). Past 30 day use of e-cigarettes ranged from 2.0% to 14.0% in the US[15 18 19 22-25 27 31]. It was reported at 7.2% in Canada[32] and 1.1% in Hong Kong[33].

Regular use was generally defined as use of an e-cigarette with regular frequency (i.e. at least once per month; see Table 1). Regular use of e-cigarettes was reported at 1.5% in the UK[34], 0.5% in Greece[35] and 3.2% in Ireland[21]. In addition, it was reported at 24% in Switzerland[a 36].

Discussion

Data from a variety of international studies suggests upward trends in adolescent awareness and use of e-cigarettes. Awareness of e-cigarettes appears to be moving towards complete awareness, with later studies reporting awareness among at least three-quarters of the adolescents surveyed. Ever-use of e-cigarettes is also higher than in previous years. Among

[a] The Swiss study grouped "several times" and "regularly" together in their analysis (see Table 1)

US samples, it is not uncommon to find ever-use rates of at least 20% among adolescents. Outside of the US ever-use is lower, but comparative studies still suggest that reported rates have doubled or tripled in recent years. Past 30 day use of e-cigarettes remains lower than ever-use, yet still seems to be on the rise in some regions. While past 30 day use was generally reported at under 10% of adolescents, it was higher among US samples with some studies reporting similar rates to non-US ever-use. Regular use of e-cigarettes is lower still, with reported rates of under 3.2% in nicotine e-cigarettes.

Awareness of e-cigarettes

Data around adolescent awareness of e-cigarettes in the previous literature is sparse, however data from the South Korean 2008 Health Promotion Fund Project suggested rates of awareness at 10.2%[37] and a survey of a 2011 nationally representative US sample reported awareness at 67%[38]. Although we do not have longitudinal data to base inferences on, the current literature review would seem to suggest that adolescent awareness of e-cigarettes is getting increasingly closer to absolute awareness. Indeed, a cross-sectional comparison of British data indicates that awareness rose from 66.8% in 2013 to 83.2% in 2014[22], which may reflect a wider trend.

Research has not directly addressed how awareness of e-cigarettes may be influenced and why awareness may have increased among adolescents. However, one of the reviewed studies reports that a 53.2% majority of North Carolina adolescents heard about e-cigarettes from television advertisements[15], which provides one possible outlet for awareness in countries where e-cigarette advertisements are not prohibited. Elsewhere, it may be the case that as e-cigarettes have become more popular among adults[1 2], adolescents have become

increasingly exposed to their use, either directly through friends and family or indirectly on the street. Nonetheless, awareness of e-cigarettes does not necessarily entail use. In both the UK and US adult populations, there is near full awareness of e-cigarettes among smokers and non-smokers, yet this does not mean that there is anywhere near full ever and/or past 30 day use of e-cigarettes among adults[1 2 38]. Although awareness is usually a prerequisite for use, it would be impossible to protect adolescents from exposure to these products and possibly undesirable to completely limit access to a potentially less harmful alternative for adolescent smokers.

Ever-use of e-cigarettes

Previous surveys have placed ever-use of e-cigarettes at 1%, 6.1%, and 10.0% in the US[38 40 41], 0.5% and 4.7% in South Korea[37 45], 8.1% in France[43] and 9.1% in Lithuania[44]. In the prior literature, analysis of Polish data indicates exceptionally high rates of ever e-cigarette use at 23.5% in 2011[45]. If we exclude the Polish data and consider that the lowest US figures are from 2011 and 2012 data, then it is clear that in recent years ever-use of e-cigarettes has shifted from under 10% of adolescents to anything between 4.7% and 38.5%. Even if we include the Polish data, some US studies and the Romanian study still display higher ever-use rates. The Romanian data displays particularly high ever-use and we would suggest that this may result from a definition of ever-use that also includes past 30 day use. However, it is also worth considering that Eastern European countries maintain higher tobacco smoking rates[46], which may also explain the high rate of e-cigarette use in Poland. This broad increase in ever use of e-cigarettes is illuminated by a cross-sectional comparison in the New Zealand data, where ever-use almost tripled from 7.0% in 2012 to 20.0% in 2014[29].

There is limited literature regarding why adolescents might ever-use e-cigarettes. In the reviewed literature, one study suggested that 34.2% of all adolescents felt that e-cigarettes were less harmful compared to tobacco cigarettes and that 71.8% of adolescent ever-users were more likely to perceive e-cigarettes as less harmful[15]. Another study indicated that 60% of all adolescents reported that e-cigarettes were safe or a minor health hazard and that 53.4% viewed e-cigarettes as less harmful than tobacco cigarettes[19]. Both of these studies open up the possibility that initial use of e-cigarettes is motivated by a relative lack of concern around any potential health risks. Unfortunately, owing to the lack of longitudinal data, we are unable to explore any relationships between ever and past 30 day use of e-cigarettes. However, the former study also suggests that ever-users are more likely than never-users to perceive e-cigarettes as less harmful[15], which could lead to more regular use of e-cigarettes. If these users have not previously been exposed to nicotine via tobacco, some have speculated that the highly addictive nature of nicotine may lead to continued use with negative developmental implications for the adolescent brain[7-9]. At the same time, it is possible that ever-users are using non-nicotine e-cigarettes, which would pose a reduced risk. Either way, as ever-use can include using an e-cigarette once across the lifetime, the extent of increased nicotine exposure as a result of ever e-cigarette use is unclear. Indeed, longitudinal research has previously suggested that adolescents may experiment with legal and/or illegal substances without becoming regular users in the long-term[47-49] and this pattern is likely to be reflected in adolescent e-cigarette ever-users.

Past 30 day use of e-cigarettes

Previous surveys in the US have documented year-on-year increases in past 30 day use of e-cigarettes in adolescents from 1.5% (2011) to 2.8% (2012)[40], 1.9% (2011) to 5.9% (2013)[41]

and 0.9% (2010) to 2.3% (2011)[50]. Elsewhere, past 30 day use was reported at 4.7% in South Korea[42], 8.2% in Poland[45] and 13% in Hungary[44]. Hong Kong appears to have maintained lower levels than those countries previously examined. However, both the US and Canada display increased past 30 day use of e-cigarettes at levels that are either comparable or higher than in all previous studies. Although longitudinal data sets are missing from the literature, it is notable that a 2011 survey of Connecticut youth suggested that 2.5% were past 30 day users[31], while a 2013 survey of the same state found that 9.4% were past 30 day users[18]. This sharp increase in past 30 day use of e-cigarettes mirrors that found in earlier US studies and may consequently represent an upwards trend in the US.

Once again, there is limited literature regarding why adolescents might be past 30 day users of e-cigarettes. However, a number of the reviewed studies report on how past 30 day e-cigarette users may use tobacco alongside e-cigarettes. Across the studies that surveyed adolescents on both e-cigarette and tobacco cigarette use, significant positive associations were regularly found between past 30 day e-cigarette use and all levels of tobacco cigarette use[14 15 19 24 26 27 29]. In particular, past 30 day users of e-cigarettes appear to have the highest use of other tobacco products. For example, in Texas 93.5% of past 30 day e-cigarette users had ever-used any tobacco product compared to 22.5% of ever e-cigarette users[22], in Ontario and Alberta significantly more (75.5%) past 30 day e-cigarette users reported past 30 day use of any tobacco, shisha, or nicotine product[28] and in the UK 80% of regular e-cigarette users had also smoked tobacco[31]. The direction of this association is not explored in the studies. Furthermore, longitudinal evidence is lacking for adolescent patterns of past 30 day tobacco use in the same samples across the same period. However, a recent meta-analysis indicates a strong association between tobacco use and all levels of e-cigarette use in both adolescent and adult populations[51]. As there are higher odds ratios of tobacco use among adolescent e-

cigarette users, it is possible that this may reflect the propensity for adolescents to engage in sensation seeking and risky behaviours[52 53]. Alternatively, if we consider recent trends in the decline of tobacco use among US adolescents reported in the 2014 Monitoring the Future survey[54], there is the tentative possibility that adolescent past 30 day e-cigarette users have been regular tobacco smokers and are dual-using or switching entirely to e-cigarettes as a means of harm reduction and/or cessation. Nonetheless, there is a clear need for future research to examine the direction of this association between tobacco and e-cigarette use.

Regular use of e-cigarettes

It is notable that three of the reviewed studies[21 34 35] reported lower rates than the majority of the North American studies that measured past 30 day use. This indicates that adolescents may be less likely to use e-cigarettes on a regular basis. Moreover, it is possible that there are cultural differences between North America and other regions that have led to different patterns of use among adolescents. Indeed, the Hong Kong study also reported low rates of past 30 day use at 1.1%[33]. In the current literature review, significantly fewer studies measured regular use of e-cigarettes. For example, none of the North American studies measured regular use. As such, we recommend that future studies measure the temporal regularity of e-cigarette use (e.g. monthly, weekly, daily), so that it is easier to discern the possible impact of cultural differences on nicotine consumption habits.

Second, it is of interest that 24% of the Swiss sample had tried e-cigarettes several times or regularly, which is higher than all of the studies that measured past 30 day use. It is entirely possible that this is a result of the combination of two quite different measurements (i.e. “several times” and “regularly”) under the same category. However, it is also worth noting

that Switzerland is the only country in the current literature review where the sale of e-cigarettes containing nicotine is entirely prohibited. This is reflected in the large number of adolescents in this study who used non-nicotine e-cigarettes (74.6% of ever-users and 70.2% of more regular users), which is significantly higher than in other studies that report on nicotine content. As such, this anomaly in the reviewed literature may be attributed to the low prevalence of nicotine e-cigarettes in Switzerland and may indicate that Swiss youth are not using e-cigarettes as a means of nicotine consumption.

The nicotine content in e-cigarettes used by adolescents is rarely surveyed in the literature, yet when it is surveyed nicotine e-cigarette use tends to be less prevalent. For example, in Ontario 10.5% reported ever using a non-nicotine e-cigarette and 4.1% reported ever using a nicotine e-cigarette[16]. Furthermore, those who had smoked tobacco in the past year were more likely to use a nicotine e-cigarette. Similarly, in Connecticut, current cigarette smokers were most likely to consistently use nicotine e-cigarettes (59.2%), followed by ever smokers (31.9%) and never-smokers (11.4%)[18]. An exception is found in the Finnish data, where 65.7% of adolescent ever e-cigarette users had used nicotine e-cigarettes[17]. However, this sample had a low rate (8.3%) of tobacco never smokers, which suggests that a number of those using nicotine e-cigarettes may have previously used tobacco. As such, the above studies support the argument that adolescent nicotine e-cigarette use is more likely among those who are ever or current cigarette smokers. At the same time, some studies report that 20.4%, 34.3% and 61% of adolescents are unaware that e-cigarettes may contain nicotine[18-20], meaning that they may not be motivated by prior or current smoking habits. Either way, future research should seek to expand our knowledge of nicotine e-cigarette use and awareness by measuring it more widely.

Limitations

The current literature review is somewhat limited by possible differences in cultural behaviours and regulations between countries. This is largely a result of the limited studies that have been carried out in different countries to date. However, it may be useful for future studies to review specific countries, or group together regions with similar cultural behaviours and regulations. In addition, the regulatory environments for e-cigarettes are constantly changing and developing. For example, the recent (May 2016) Tobacco Products Directive (TPD) will change the ways in which e-cigarettes are advertised, sold and used across the EU. As such, we highlight and recommend the need for regular literature reviews of adolescent awareness and use of e-cigarettes, so that the research and practitioner communities can remain up-to-date with this dynamic area.

Conclusions

To date, the literature has rarely examined patterns of nicotine and non-nicotine e-cigarette use. If adolescents are ever using flavoured non-nicotine e-cigarettes, then this behaviour is not necessarily problematic, aside from any potential risks posed by other constituents in the vapour. On the other hand, although e-cigarettes may be less harmful than tobacco cigarettes, if the user has never smoked tobacco then the use of nicotine e-cigarettes would involve unnecessary exposure to nicotine. Limited data does indicate lower prevalence of e-cigarette use among adolescent never smokers of tobacco. However, it also indicates that a small proportion of e-cigarette users do not know whether their e-cigarettes contain nicotine or not. Consequently, it may be important to explore health education strategies aimed at informing adolescents about e-cigarettes and the possible risks involved with their use.

In addition, there is a need to investigate how past 30 day e-cigarette use may be associated with tobacco abstinence, or a lack thereof. At present, it seems clear that past 30 day adolescent users of e-cigarettes are more likely to use other tobacco products. However, the nature of this association is unclear and it is important to discern whether regular use of e-cigarettes is assisting adolescent smokers with tobacco abstinence or introducing adolescent non-smokers to tobacco. As such, longitudinal studies that track the trajectory of use would greatly aid our comprehension of how adolescents are using e-cigarettes in relation to tobacco. Moreover, it is important for future studies to utilise qualitative methods as a means of exploring in-depth how and why adolescents are using e-cigarettes. By answering these questions in future research, we can move forward in understanding the extent to which e-cigarettes pose either a risk to adolescent public health, or represent an opportunity to assist with adolescent smoking prevention or cessation efforts.

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