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Measuring Exposure Opportunities: Using Exogenous Measures in Assessing Effects of Media Exposure on Smoking Outcomes

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Abstract

Measurement of exposure has long been one of the most central and fundamental issues in communication research. While self-reported measures remain dominant in the field, alternative approaches such as exogenous or hybrid measures have received increasing scholarly attention and been employed in various contexts for the estimation of media exposure; however, systematic scrutiny of such measures is thin. This study aims to address the gap by systematically reviewing the studies which utilized exogenous or hybrid exposure measures for examining the effects of media exposure on tobacco-related outcomes. We then proceed to discuss the strengths and weaknesses, current developments in this class of measurement, drawing some implications for the appropriate utilization of exogenous and hybrid measures.

Keywords

exogenous exposure measures; content analysis; ratings; media exposure; media effects; smoking

Introduction

Over the past few decades, abundant research evidence supports claims that exposure to media content shapes tobacco-related outcomes. Many of these studies examine effects of deliberate campaigns, but others also show that exposure to tobacco-related information through routine media use affects behavior. This set of tobacco studies provides a coherent database to permit a systematic examination of how exogenous measures are used in one field, but will allow discussion of the implications for exposure measurement across domains.

The studies supporting these claims of media effects take three broad approaches to assessing exposure to media. Some studies compare people based on an assigned intervention status: in an experiment, those in the treatment versus control group; in an over-time design those measured before versus after the initiation of an intervention; in a cross-geographic-unit design, those in intervention versus control zones. Measurement of exposure in these intervention studies is straightforward, defined by assignment to condition.¹ However, many such studies discover that treatment assignment is not enough to assure

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actual exposure, and they additionally assess individual exposure, often with the second broad approach, self-reports.

Self-reports allow researchers to assign individuals to personal exposure estimates and to relate that exposure to measured outcomes. However self-reports of exposure may face challenges such as recall bias, fallible memory and social desirability. When they are used in effects studies, these concerns focus on the issue of endogeneity. Because the measures of exposure and outcome are (typically) both assessed on the same survey instrument, there is a concern about their independence; while an observed association may be the result of a causal process running from media exposure to the purported outcome, it may also reflect either the effect of third variables on both measures, or of reverse causal direction (e.g., people who quit smoking successfully may be more likely to recall seeing anti-smoking ads). While researchers utilize a range of solutions to reduce this concern with endogeneity (e.g., over-time studies, propensity scoring, instrumental variables), these solutions cannot always be implemented convincingly. Some researchers have turned to a third class of exposure measures, exogenous measures, to address this concern (Fishbein & Hornik, 2008; Niederdeppe, 2014; M. Slater, 2004).

Exogenous measures, also known as ecological or unobtrusive measures, are assessed independently of measures of outcomes. Compared to self-report measures of exposure, which try to capture individual differences in the direct encounter with media messages, exogenous measures estimate the *possibility or opportunity for exposure*. They assess exposure possibilities in the environment of individuals and try to show that such exposure opportunities are related to outcomes either across time or over geographic locations. There are five broad categories of exogenous measures: (1) content analysis; (2) media ratings – gross or targeted rating points; (3) advertising expenditures; (4) records of promotional information at retail point-of-sale locations, and (5) hybrid measures that integrate self-reported information with one of the above four measures.

Previous systematic reviews and meta-analyses investigating the relationship between media exposure and health behavior outcomes have synthesized studies that either focused solely on self-reports of exposure or have not distinguished different types of exposure measurements (e.g., Charlesworth & Glantz, 2005; Durkin, Brennan, & Wakefield, 2012; Forsyth, Kennedy, & Malone, 2013; Lovato, Watts, & Stead, 2011; Wakefield, Loken, & Hornik, 2010). Most recently, Niederdeppe (2014) elaborated on the validity issues related to different classes of campaign exposure measurements, but the review had a heavy focus on self-report measures. To our knowledge, there has not yet been a systematic effort specifically targeting studies that used exogenous measures.

The current study presents such a systematic review of studies which utilized exogenous exposure measures for examining the effects of media exposure in the tobacco domain, where the richest lode of relevant studies was likely to be retrieved (Wakefield et al., 2010).

¹Logically, assessing exposure based on assignment to condition is similar to the forms of exogenous measurement described in detail below, subject to the primary advantages and disadvantages (i.e., independence from outcome measures, but the risk that assignment and actual exposure are not closely related). Nonetheless, this form of exposure measurement belongs to a different tradition of exposure measurement, and we do not address it in detail here.

We focus primarily on examples within the context of a single literature to simplify the search process, to allow for more straightforward comparisons, and to better demonstrate the logic of this measurement approach. Nevertheless, the conceptual issues surrounding exogenously measured media exposure should have broader application.

We first present a general review of studies that have gauged media exposure exogenously according to the five categories mentioned above. Example studies within each category illustrating how the approach has been used are summarized in an associated table. The surrounding text points to some noteworthy dimensions on which the individual studies within each category may vary. The online appendix offers a more detailed and comprehensive review for studies in each category. The second part of the paper discusses the strengths and weaknesses of exogenous exposure measures as they have been used. It also discusses current developments, their likely future trajectory, and implications for better utilization of exogenous exposure measures.

Review of Research that Used Exogenous Exposure Measures

We searched electronic databases with the following inclusion criteria: studies used exogenous exposure measures, addressed tobacco-related outcomes, made claims about media effects, and relied on quantitative methods. The overall inclusion and exclusion process resulted in 80 studies identified as eligible. Details of literature retrieval procedures are provided in the online Appendix I.

The review of these studies addresses each of the five broad categories of exogenous exposure measures.

Content Analysis

Content analytic studies have a long tradition in communication science. Media exposure measured by content analysis implicitly characterizes aggregate opportunities for exposure which are linked to outcomes over-time or across geography.

While traditional manual coding is still dominant in the field of communication, a burst of interest in automated methods in recent years has enabled the efficient processing and classification of the vast amount of textual data currently available. The application of manual coding is usually bounded by the sample sizes that human coders can handle, the difficulty for human coders to detect some hidden patterns in the texts, and the requirement of predefined categories that might not always respond to evolving changes in themes, categories and concepts. Machine-based coding, including dictionary-based approaches, machine learning approaches, as well as digitally obtaining or monitoring frequency of articles or mentions stored in online archives (e.g., Google News, Baidu News), allows for automated classification of much larger samples. Moreover, it is linked to evolving procedures of machine learning algorithms, thus can push coding itself beyond what traditional human coding permits. However, machine coding tends to be less flexible compared to human coding when the task requires gauging the exposure to latent or abstract content in the media (Grimmer & Stewart, 2013; Petchler & González-Bailón, 2013).

Scholars also use content analysis to assess either the volume of potential exposure, or to quantify the availability of particular content characteristics or features in the media, including but not limited to theme (e.g., health, economics, second-hand smoke), type (e.g., news story, editorial), tone (e.g., pro, neutral, anti), prominence (or placement) and stylistic features (e.g., personal testimonial, graphic imagery). In the investigation of media effects, content-analyzed media coverage is usually aggregated by time or geographic locations, and then such estimates of potential exposure will be merged with self-reported or archival outcomes that share the same aggregate-level unit of analysis.

Our literature search found 14 studies that relate content-analyzed exposure to smoking-related outcomes (see Appendix II-1 for details on each study). Table 1 points to a few example studies in the tobacco domain along two major coding dimensions: manual versus machine, and volume versus characteristics.

Commercial TV Ratings

Another common approach for estimating potential media exposure is through commercial ratings data provided by network and cable TV monitoring services like Nielsen. Two types of ratings data metrics were most used in quantifying media exposure: GRPs and TRPs. *GRPs* or Gross Rating Points, estimates the number of views among individuals of a certain program or advertisement within a specific media market during a particular period of time (Farris, Bendle, Pfeifer, & Reibstein, 2010). GRPs are the product of the reach of a program (the percentage of the audience who saw it) and the frequency of viewing among those who saw it. *TRPs* stands for Target Rating Points, and refers to GRPs for a more narrowly targeted audience (e.g., the TRPs for 18–35 year olds). Ratings provide estimates of average opportunities for exposure either across time or media market or both, but not individual exposure.

Our literature search located 24 ratings-based studies in the tobacco domain (see Appendix II-2 for details of each study). In Table 2, we provide brief descriptions of a few examples. They represent two major dimensions characterizing studies that employ ratings data: whether they focus on GRPs versus TRPs, and whether they use time versus media market as the unit of comparison.

Unobtrusive Records of Point-of-Sale (POS) Ads

Point-of-sale advertising is an established marketing strategy that attempts to target consumers at the places where they purchase products. On-site unobtrusive observations of POS ads quantify exposure opportunities through this channel. Trained research staff use established protocols, and unobtrusively observe and record the type, content and intensity of (visual) ads and promotions of interests in the targeted retail environment (e.g., Feighery, Ribisl, Schleicher, Lee, & Halvorson, 2001).

POS tobacco advertising has become an increasingly important venue for the tobacco industry to promote their products, especially targeting adolescents, considering the restrictions on tobacco marketing in other media channels. Our literature search identified 5 studies that have employed this method to estimate tobacco ad exposure at POS outlets and related that to measures of smoking-related outcomes (see Appendix II-3 for details of each

study). Four of the studies gauge POS ad exposure and compare it to average tobacco use both aggregated to the residential catchment area. In recent years, development of novel technologies such as geo-tracking also facilitates assigning POS ad exposure at the individual level. In Table 3, we briefly describe two example studies with one of them unobtrusively recording the POS tobacco ad exposure at the aggregate level and the other at the individual level.

Advertising Expenditures

Scholars have also been using advertising expenditure data to estimate potential exposure due to relative accessibility to such data, and the easy assumption that money spent reflects credible judgment about exposure and its expected impact (Chung & Kaiser, 1999; Cowling, Modayil, & Stevens, 2010). The logic for the use of expenditures is quite similar to that for measuring exposure with GRPs or TRPs, since ratings often reflect expenditures. However, GRPs can vary with the availability of donated or discounted advertising time for public service advertising, and with purchase of advertising time under circumstances when there are different costs per person reached by media channel or time of day. Additionally, expenditure data may be available to researchers when GRPs are not. Expenditures are also particularly useful as a unit because they reflect what an interventionist needs to spend rather than an estimate of what exposure might be achieved with a particular media buy.

Our literature search found three studies that have used expenditures as a proxy for media exposure in relation to media effects (see Appendix II-4 for details of each study).² In Table 4, we highlight two example studies with one of them focusing on the impacts of tobacco companies' brand-specific commercial advertising, and the other on the effects of a state-sponsored anti-tobacco campaign's ads exposure.

Hybrid Measures: Self-reported plus Exogenous Measures

Exogenously measured media exposure is informative when the goal is to understand a population-level effect where total exposure in a media market affects corresponding smoking prevalence in this area, and the effects happen through a social or institutional process rather than just an individual process (Hornik, 2002; Hornik & Yanovitzky, 2003). However, individuals may have actually seen more or less of the media content than the average person in a given media market or in a given year. To address this concern, another group of studies have used hybrid measures. They use GRPs or analyses of content to assess opportunities for exposure at the aggregate level, and self-report data to capture individual differences in likely exposure to the medium where the content appears. For example, a content analysis describes smoking behavior in a set of popular movies, and surveys permit youth to indicate whether they have seen the movies. The hybrid measure assigns each youth to a level of exposure to smoking content based on whether or not he or she has seen movies that have smoking content as suggested by content analysis. Similarly, survey measures

²We excluded several studies that examined the impacts of the overall tobacco control funding. These should not be deemed as clean measures of media exposure considering that tobacco control programs usually consist of a variety of components, such as interventions, grant programs, media campaigns, education programs etc. (e.g., Chattopadhyay & Pieper, 2012; Farrelly, Pechacek, & Chaloupka, 2003; Lightwood & Glantz, 2011, 2013; Max, Sung, & Lightwood, 2012; Pierce et al., 1998).

capturing individual differences can be combined with any of the types of exogenous measures presented above.

We have found 34 studies in the tobacco domain that have employed hybrid measures to gauge media exposure in relation to effects. The great majority of these studies (26 out of 34) have focused on combining surveys and movie content analysis (named the “Beach Method”; Sargent, Worth, Beach, Gerrard, & Heatherton, 2008). Of the remainder, three focused on combining surveys and content analysis of other media types; two combined surveys and GRPs of ads; two combined surveys and POS advertising observations; and one used both surveys and ad expenditures on magazines to assess exposure opportunities (see Appendix II-5 for details of each study). Four example studies are presented in Table 5.

The Strengths and Weaknesses of Exogenous Measures

In this section, we examine the strengths and weaknesses of using exogenous measures both generally and for specific measures, discuss research questions each measure would be best suited for, and outline potential problems scholars or campaign evaluators might encounter with these measures.

Strengths in General

Mitigating concerns about reverse causation—The most important advantage of using exogenous measures is to mitigate concerns about reverse or reciprocal causality, or endogeneity (M. Slater, 2004), which is often a fundamental challenge in media effects studies that use self-reported exposure measures. Due to the non-disruptive and non-reactive nature of the exogenous measures, the subjects are unaware of the exposure measurement, and individual selectivity or any atypical response unwittingly elicited by interviews or questionnaires would be less likely to affect the estimation of exposure, thus helping support stronger causal inferences.

Reducing concerns about inaccurate estimation from respondents—It is well-known that individual differences in the engagement with the topic, prior knowledge, and social desirability might lead to biased self-reports of exposure (M. Slater, 2004; Wonneberger, Schoenbach, & Meurs, 2013). Individuals’ ability to remember precisely also varies (Southwell et al., 2010; Southwell & Langteau, 2008; Tourangeau, 2000). In addition, exposure could be consequential even when the media content has not been sufficiently well-attended to at the moment of exposure to be recalled later (Prior, 2009; M. Slater, 2004). These problems may be exacerbated in the current media-saturated environment: new technologies proliferate, media becomes increasingly mobile, and matching sources and content becomes a tougher memory task (Valkenburg & Peter, 2013). Exogenous measures which eliminate or reduce (for hybrid measures) reliance on self-reports lessen these concerns.

Capturing effects that are shared within a geographic unit or a time period—Media content might influence individual cognitions and behaviors through both direct and indirect pathways. Direct pathways focus on individual differences in exposure; indirect pathways focus on the effects of exposure on the people and institutions around an

individual that in turn affect the individual (Hornik, 2002). Exogenous measures based on aggregation of exposure reports in a shared geographic unit may capture both paths of effect while individual self-reports may only capture effects resulting from direct exposure (Fishbein & Hornik, 2008; Hornik & Yanovitzky, 2003; Stryker, 2003). For example, higher campaign ad GRPs in a targeted community could simultaneously produce higher individual-level direct exposure, but also interpersonal conversations about the ads, and lead to policy makers generating new policy initiatives, all of which may shape prevalent normative perceptions in the community.

Weaknesses in General

Not real exposure, but opportunities for exposure—Exogenous measures can only assess exposure opportunities, an “upper bound” estimate of the potential reach of media content. However, the opportunity for exposure is not equivalent to actual exposure. People in the rating-claimed audience for a program may not be physically present or pay any meaningful attention to the message. Exogenous measures are relatively coarse measures, saying little about whether the audience is in an attentional, automatic, transported, or self-reflexive state during the exposure encoding, and how much cognitive effort they have applied to understanding the messages (Fishbein & Hornik, 2008; Niederdeppe, 2014; Potter, 2008).

Same exposure score assigned to everyone—Exogenous measures are also especially prone to suffering from “ecological fallacy” problems such that individual exposure is inferred from or assigned by the aggregate-level estimates, although the actual individual exposure will vary from the mean exposure within the same geographic or temporal unit (Robinson, 2009; M. Slater, Snyder, & Hayes, 2006).

Mitigate risk of reverse causation, but it is not completely eliminated—While exogenous measures reduce the risk of reverse causation to some extent, they do not eliminate it. For example, governments or campaign planners may choose to put more anti-smoking ads in media markets where they think there is more openness to change and have a better chance of success, and judge openness by information about current smoking levels within different markets. In that situation, the purported outcome – current smoking behavior – influences the purported causal variable – the level of GRPs offered in a media market.

Possible concerns with self-selection biases—Research which relies on exogenous measurement remains subject to concerns that some other variable affects both the exogenous assessment of exposure and the measures of an outcome. For example, evidence that media markets with more exposure to anti-smoking ads have lower rates of smoking initiation, may face concerns that other characteristics of those markets (e.g., educational level or community norms opposing smoking) affect both the frequency of ads broadcast and the level of smoking. The specifics of designs in which exogenous measures are incorporated may make such threats of greater or lesser concern.

May still be based on survey data; an independent but not an “objective”

assessment of exposure—Some exogenous measures are dependent on survey data. TV ratings are still largely dependent on individual survey responses or meter data quality. The current discussion of such ratings include concerns that the sample households and individuals who agree to participate may not be representative, that ratings may not capture all forms of viewing equally well, and that reports may reflect the biases of all self-report measures, resulting in over- or under-reporting of some program viewing. Still, a large proportion of advertising expenditures reflect such ratings, and that usage provides an implicit endorsement of their acceptable accuracy. Viewing estimates for major network programs in large cities for the entire population may be quite stable because they are based on large samples, although estimates for niche programs in smaller media markets (where metered households are fewer) may be less stable.

Difficulty in cross-source exposure aggregation—Campaigns may plan for exposure through a variety of sources. Even if exogenous exposure estimates for each source were accurate, exogenous exposure to a set of sources can be hard to estimate. Individuals can self-report exposure to each source, and thus summing across sources from self-reports, taking into account the tendency to use multiple sources, is feasible. However, at the aggregated level this is a more difficult problem. Summing aggregated measures across sources cannot be done by simply adding up the source specific information. It also requires taking into account whether individuals who use one source are more likely to use another. While commercial media buyers make such estimates regularly, estimates of exposure across sources are likely to be quite noisy. Hybrid measures might alleviate this problem to some degree by incorporating the self-reported media use pattern data as weights when aggregating across sources.

Measure-Specific Considerations

There are also unique advantages and disadvantages associated with different types of exogenous measures. In this section we discuss both method-specific pros and cons and comment about when particular methods may be valuable.

Content Analysis—Unlike the other forms of exogenous measurement, content analysis permits estimation of the potential exposure to specific elements of media content, such as genres, types, valence, themes and prominence (M. Slater, 2004, 2013). Some research questions that content analysis is most suited to answer are, for example, “what are the relationships between the volume and the use of different themes and stylistic features of ads employed in state antismoking campaigns, and state youth smoking prevalence?” (Niederdeppe, Avery, Byrne, & Siam, 2014), and “in an online social network for smoking cessation, if users are exposed to more positive than negative messages about a cessation drug, will the odds of them switching to this medication be significantly increased?” (Cobb, Mays, & Graham, 2013). The downside of using this measure, especially for the manually conducted content analysis, is that it can be very labor-intensive, limiting the scale of the studies, possibly reducing representativeness and statistical power to detect small effects. In addition, inter-coder reliability is often hard to achieve with subtler ideas. Machine-based coding can overcome labor concerns and might be perfectly reliable; however, rigorous and

iterative validation processes are needed to avoid serious errors, and it might be challenging for machine classifiers to code latent instead of manifest content (Grimmer & Stewart, 2013; Potter & Levine-Donnerstein, 1999). Finally, there may be no accessible media content archive that is ideal for answering particular research questions (e.g. an investigation on over-time effects of TV images of LGBT people requires an archive of programs to perform content analysis on, which may not be available).

Commercial TV Ratings—Ratings data could facilitate assigning frequent and comparable measures of exposure over a long period of time using standardized metrics. They also provide the opportunity to estimate both short-term and long-term effects of different densities of exposure with varying discounting assumptions about duration of exposure effects (Wakefield et al., 2006; Wakefield, Spittal, Yong, Durkin, & Borland, 2011). This measure is particularly good at answering research questions such as “what are the relationships between US adults’ exposure to smoking-related television advertisements sponsored by state health departments, the American Legacy Foundation, tobacco companies, and pharmaceutical companies, and their smoking behaviors from 1999 – 2007?” (Emery et al., 2012), and “are amount of exposure and broadcasting recency of televised ads positively associated with ad recall? Is there a diminishing effect of increased ads exposure on recall?” (Dunlop, Perez, & Cotter, 2012). However, some uses of ratings may raise concerns. Comparisons across media markets, if some of those markets (and survey sample sizes) are small and the GRPs are purchased on niche programming, may be unreliable because market-specific GRP estimates are unstable. Also, TV ratings data may not be available for some study-relevant audiences (e.g., TRPs for young African-American men may not be available across markets). Another possible weakness of ratings data is the lack of separate information about reach and frequency. Expected effects in a market may be quite different for low reach, high frequency messages versus high reach, low frequency messages.

Unobtrusive Observations of Point-of-Sale (POS) Ads—Unobtrusive observational in-store assessment is flexible in obtaining information about real-world POS tobacco retail marketing, including ads, promotions, product placement and prices (Berman & Kim, 2015). It is most useful in answering questions like “are higher levels of POS tobacco ads exposure in stores located in the school neighborhood related to school smoking prevalence?” (Lovato et al., 2011). A primary limitation of this measure is that manual observations to record all the different POS ads can be labor intensive and error prone which limits its application. In addition, while employment of geospatial tracking technology in these studies offers to quantify individualized exposure opportunities, it also requires difficult-to-achieve cooperation among research participants (Duncan et al., 2014).

Advertising Expenditures—Ads expenditure data promises to serve as a proxy for exposure especially for large-scale comprehensive campaigns where there are multiple channels of media exposure going on, and it is hard or impossible to estimate each activity or channel in isolation. The data may be relatively easy to obtain and use a single metric (e.g., dollars) for comparison across sources. Expenditures also directly address the question of how much funding is needed for exposure to have effects for purposes of campaign

planning and evaluation. One example research question would be “what is the association between California’s antismoking media placement expenditures and consumer behaviors toward smoking there?” (Hu, Sung, & Keeler, 1995). The use of ads expenditures data assumes that expenditures reflect the value advertisers give to the exposures purchased in the market. However, the mechanism of how campaign money is translated into actual exposure, and then further translated into smoking-related outcomes remains a “black box”, considering that expenditures must work through several intermediaries such as campaign strategy, advertising content, and advertising frequency to achieve campaign effects. Furthermore, spending measures sometimes are not comparable across media markets because the amount of advertising a campaign dollar will buy might vary geographically. In the absence of complementary and detailed content analyses of ad content, expenditures may not permit addressing more complex questions of effects.

Hybrid Measures—The greatest advantage associated with hybrid measures is that they capture individual variation with reduced threats to inference from reverse causation. This type of measure combines self-reported media use preferences, habits, or patterns with exogenously obtained media content availability data. Ordinary self-report measures ask respondents to recall exposure to specific content – for example the number of tobacco ads seen in the previous 30 days, or how many movies they saw where the lead characters smoked. These are hard memory tasks, and recall may be affected by interest in smoking that might also be the outcome of interest. In contrast, hybrid approaches use self-reports for easier tasks and for information where recall is less likely to be influenced by focal outcomes (e.g., they only ask whether an individual has seen a movie and do not mention tobacco content). Thus they enjoy the strengths of both self-reports and exogenous measures by permitting easier recall (presumably less recall bias) and reduced risk of reverse causation while still allowing exposure scores to be assigned to individuals. Hybrid measures are particularly good at answering research questions such as “is exposure to smoking in the movies among adolescents related to ever smoking?” (Morgenstern et al., 2011). There are also potential weaknesses associated with hybrid measures. If exposure estimates rely on self-reports of media use (even if they are combined with independent content analyses) that are then compared to self-reports of outcomes, there is enhanced risk of endogeneity compared to other exogenous approaches; it might be that some other variable influences both media use and the focal outcome. For example, in the case of relationship between smoking in the movies and smoking initiation, it might be that parents who allow adolescents to attend R-rated movies where smoking is more likely also are more permissive about smoking.

Future Directions: Where Next?

Most of what we found in the tobacco domain, and likely the same would be true for other domains, is about conventional media exposure. This review followed where the evidence is. But how can we extend the arguments in a changing media environment? It is possible to do so in two directions. First, new technologies both represent different forms of exposure and create fresh challenges for measurement. Second, exogenous measurement is an active area

for methodological research, and current innovations exploit evolving digital technologies. This section points to some of those new challenges and opportunities.

New Text Sources Available: Social Media

With the rapid rise of the Internet and evolving digitization technology, the opportunities for electronically storing, extracting and processing digital text archives have expanded unprecedentedly. Social media such as Twitter and Facebook both raise new research questions and offer enormous amount of text for exploration (Cardie & Wilkerson, 2008). Most of the existing studies about tobacco-related content on social media are descriptive (e.g., Carroll, Shensa, & Primack, 2013; Forsyth & Malone, 2010; Freeman & Chapman, 2010). Though studies have started to pay attention to the behavioral effects of tobacco-related content on new media, they mostly still employ self-reported measurement to assess media exposure (e.g., Depue, Southwell, Betzner, & Walsh, 2015). A potential direction for future studies would be to both capture exposure to new media, by summarizing what is on publicly available streams (e.g., Twitter) over time, and examine whether variations in the content of those streams predicts changes in parallel public opinions and behaviors.³

Digital Surveillance and Automated Content Analyses

The proliferation of easy-to-obtain and immense volumes of electronic textual data has underpinned the growth of automated content analysis where researchers can employ a predetermined dictionary approach or machine learning methods (supervised, unsupervised, semi-supervised) to minimize human labor (González-Bailón & Paltoglou, 2015; Grimmer & Stewart, 2013; Schwartz & Ungar, 2015). Researchers can also exploit other digital surveillance tools such as Google Trends which provide information about relative quantities of searches for specific words or phrases, across time and geography. Again, descriptive analyses about the online prevalence of specific topics are available but do not yet address media effects (e.g., for digital surveillance: Ayers, Althouse, & Emery, 2015; Ayers, Althouse, Ribisl, & Emery, 2014; for automated content analysis: Emery, Szczypka, Abril, Kim, & Vera, 2014).

Automated Point-of-Sale Recording

Current POS research relies on observers counting ads in specific stores matched up with information about individual visits to those markets. Newer technology offers opportunities to both automate the recording of ads in stores (through technologies like Google Glass) and the collection of information about individual proximity to stores through geospatial recording technology. The geospatial method has already been incorporated into some of the research described above, which also used cell phone prompted ecological momentary assessment for measuring outcomes (Kirchner et al., 2013).

³Our research group has such a study underway. Funded by the US Food and Drug Administration, it is gathering time-series data over 42 months from multiple online sources to assess changes in what is being said about tobacco in the public communication environment, and simultaneously doing matched monthly sample surveys of a US national population of youth and young adults to assess outcomes.

Finally, in addition to the above new future directions that focus more on exploration of digital technology, another less implemented measure, which is relevant to both conventional and digital media, deserves future attention.

Aggregated Survey Data

Most of the previous studies employing exogenous measures deliberately avoided estimating self-reported exposure on the sample from which individual outcome measures were obtained, to avoid the threats related to endogeneity. However, if the two samples (i.e., one for estimating exposure and the other for estimating outcomes) do not come from the same unit of exposure assignment (defined by geography or time), such mismatch might be problematic. One approach to reducing this risk may be to estimate exposure by aggregating the individual self-reports from the same sample survey in which outcomes are estimated. These self-reports would be aggregated to the level of relevant geographic or temporal units. The aggregated self-report exposure estimate is (substantially) exogenous to each single individual in the sample (if each sample is large enough so that any single individual's contribution to the aggregated score is trivial). For example, if every respondent in a sample provided an estimate of exposure to anti-tobacco ads in the past 30 days, the mean exposure score for all respondents in a particular month could be used in the same way a rating-based or content-analysis-based estimate of exposure for that 30-day period would be used. Thus the association of aggregated self-reported exposure information with individual survey outcome measures would provide evidence about effects.

The advantage of aggregated self-reports versus other exogenous measures is that the exposure estimates and the outcome estimates would be based on the same populations. Additionally, the survey questions used to estimate exposure could be formulated for the precise needs of the study. In contrast, other exogenous measures may be limited to what may be available in secondary sources. Otherwise such aggregated self-reports would likely be subject to the same strengths and weaknesses outlined for exogenous measures more generally. One particular concern for this type of study would be that it would depend on having a large enough sample for each time or geographic unit of exposure assignment so that mean estimates would be statistically stable, and effectively independent of reports by single respondents. Currently no studies found in the tobacco domain employed such a method to estimate exposure.

Concluding Remarks

Need for Validation

The best measures are always those that can provide a clear advantage in validity (Krippendorff, 2009; Lee, Hornik, & Hennessy, 2008; Niederdeppe, 2014). In our sample, few effects studies have explicitly provided validity evidence for their exogenous exposure measures: Emery et al. (2005), Dunlop et al. (2012), Wakefield et al. (2006), and Richardson, McNeill, et al. (2014) found evidence for the association of TRPs and average ad recall; several studies using the hybrid "Beach Method" measure demonstrated that adolescents rarely reported seeing either bogus film titles with false actors or the bogus film titles with real actors (Sargent et al., 2001, 2002; Thrasher, Jackson, Arillo-Santillán, &

Sargent, 2008); Cavazos-Rehg et al. (2014) found that states with higher relative volumes of Google searches for specific tobacco products had higher prevalence of use. Other than these studies, no other validation evidence for exogenous measures was found in the current sample of studies. Considering that the exogenous exposure measures are gaining popularity among media effects studies, and that the progress of media effects studies will depend heavily on the quality of exposure measurement, the need for additional validation evidence is clear. Potential approaches would include: associating over-time variation in media coverage of an issue, for example, with over-time survey reports of exposure (e.g., Kelly, Niederdeppe, & Hornik, 2009), or testing whether over-time variation in coverage of a topic in one media source is associated with coverage in another source (e.g., Guggenheim, Jang, Bae, & Neuman, 2015).

Three General Guidelines

Here we address three general guidelines for employing exogenous measures in the investigation of media effects that have direct implications for practice. All of them, we believe, are relevant across domains.

First, match the research approach to the assumed paths of effects. There exists no single conceptualization of how exposure affects outcomes, and different exposure assessments should reflect different underlying research goals and the corresponding proposed pathways through which the effects are assumed to be produced (Hornik, 2002; Romantan, Hornik, Price, Cappella, & Viswanath, 2008; Stryker, 2008). For example, in the evaluation of large-scale complex campaigns where effects are expected to occur through social, institutional, as well as individual learning processes, assessing exposure only at the individual level through self-reports may be problematic. Aggregated measures may better capture supra-individual processes while they may be less sensitive to the discrete individual-level learning process. Therefore, exogenous or hybrid measures alone or as a complement to individual difference measures should serve better here to capture the complete picture of individual, social and institutional processes through which the exposure has effects.

Second, try to assess individual differences in exposure even when making use of aggregated estimates. Hybrid measures enjoy strengths of both self-reported and exogenous measures, reducing endogeneity concerns while being responsive to individual differences. Allowing individual variation complementary to the aggregate-level exposure estimation, by either assigning weights according to personal habits, or modeling under multi-level models, may allow exposure to be a better predictor of effects while maintaining the advantages of exogenous measures.

Finally, recognize that all exposure is not equal, and aggregated measures which take into account the nature of relevant content elements may be more useful than simple volume measures – simple GRPs without elaboration as to specific content may lose effects that are contingent on content. Consider the interaction effects between amount of exposure and some aspects of content elements. Several studies complement the use of GRPs with content analyses methods and found interesting patterns that would otherwise not be revealed if only volume but not content was incorporated (e.g., Dunlop et al., 2012; Richardson, Langley, et al., 2014).

To conclude, there is an overarching theme of this review and can be briefly summarized as — exogenous measures of exposure have much value, but they require thoughtful application. They need to be responsive to expected models of influence; they need to struggle to respect individual differences despite appropriate concerns about endogeneity; and there is promise in combining available approaches to maximize validity and responsiveness to models of influence.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1**Summary of Content-Analyzed Exposure Measure Categories and Examples**

<i>Measure Categories</i>	<i>Description of Example Studies</i>
Manual coding for content volume	<p>Pierce & Gilpin (2001) assessed the volume of US news coverage on smoking by counting the number of articles under tobacco-related headings published annually in major magazines between 1950 and early 1980s. They also estimated yearly smoking cessation and initiation rates in the US from the NHIS, a nationally representative survey for the same period of time. With year as the unit of analysis, they found that the reported incidence of cessation (but not initiation) mirrored the pattern of magazine news article coverage on tobacco among youth and young adults.</p> <p>(Other studies in this category include: Asbridge, 2004; Jamieson & Romer, 2014; Niederdeppe, Farrelly, Thomas, Wenter, & Weitzenkamp, 2007; Niederdeppe, Farrelly, & Wenter, 2007)</p>
Manual coding for content characteristics	<p>Smith, Siebel, et al. (2008) collected 2 months of newspaper articles on tobacco from all daily U.S. newspapers and content coded for both overall volume of tobacco-related and second-hand-smoke (SHS) theme-specific news coverage. States were the unit of analysis; volume of SHS coverage was weighted by each newspaper's circulation in the state. There was no evidence that state volume or tone of overall tobacco news was associated with state-specific survey measured attitudes towards smoking bans, or support for restaurant bans. However, states exposed to more SHS-specific news coverage were less likely to support restaurant smoking bans.</p> <p>(Other studies in this category include: Harris, Shelton, Moreland-Russell, & Luke, 2010; Niederdeppe et al., 2014; Sato, 2003; Smith, Wakefield, et al., 2008)</p>
Machine-based coding for content volume	<p>Ayers et al. (2012) examined weekly news stories archived on Google News that mentioned quitting smoking, and search queries on the same topic archived on Google Trends from 2006 to 2011 in Latin America. Their findings suggested that cessation news coverage and queries were not strongly associated when comparing across the entire time series. However, there were substantially higher correlations when they focused on time periods around World No Tobacco Day when the variation in news coverage and searches was presumably much larger.</p> <p>(Other studies in this category include: Cavazos-Rehg et al., 2014; Huang, Zheng, & Emery, 2013)</p>
Machine-based coding for content characteristics	<p>Cobb et al. (2013) applied automated dictionary-based content analysis and sentiment analysis on free-form texts from an online smoking cessation public forum mentioning a controversial cessation medication. They coded the emotionality of the messages that were available in the forum for 30 days after each individual registered, and used that to predict registrants' self-reports of initiation or rejection of the aid over the 30-day period. They found that as the exposure to positive messages outweighed negative ones, registrants' odds of switching to and continuing to use this cessation medication increased significantly.</p>

Table 2**Summary of Ratings Exposure Measure Categories and Examples**

<i>Measure Categories</i>	<i>Description of Example Studies</i>
GRP data aggregated across time	<p>Langley, McNeill, Lewis, Szatkowski, & Quinn (2012) examined the relationship between the monthly TV GRP data of two types of ads and smoking cessation activity in England and Wales as measured by archive records such as monthly calls to the National Health Service stop smoking helpline and monthly rates of over-the-counter sales and prescribing of nicotine replacement therapy (NRT). They concluded that tobacco control campaigns compared to NRT ads funded by pharmaceutical companies were more effective at triggering quitting behaviors.</p> <p>(Other studies in this category include: Nonnemaker et al., 2014; Pierce, Anderson, Romano, Meissner, & Odenkirchen, 1992; Richardson, Langley, et al., 2014; Richardson, McNeill, et al., 2014; Sims, Langley, et al., 2014; Sims, Salway, et al., 2014)</p>
GRP data aggregated across media markets *	<p>Emery et al. (2012) calculated depreciated cumulative GRP measures based on the survey date and media market in which people resided to estimate US adults' exposure to anti-tobacco television ads from 4 different sponsor sources, and combined these data with individual-level self-reported smoking related outcome measures. The results showed that the anti-tobacco advertisements sponsored by states and the American Legacy Foundation predicted reductions in adult smoking, while the effects of exposure to advertisements for pharmaceutical cessation aids were inconsistent, and the tobacco industry-sponsored advertisements predicted lower quit levels.</p> <p>(Other studies in this category include: Durkin, Biener, & Wakefield, 2009; Farrelly et al., 2012; Wakefield et al., 2011; Zhang, Vickerman, Malarcher, & Mowery, 2014)</p>
TRP data aggregated across time	<p>Wakefield et al. (2008) merged the monthly TRPs for televised tobacco control ads from governments or public health organizations and direct-to-consumer ads of NRT by pharmaceutical companies with self-reported adult smoking prevalence assessed by survey data from the capital cities of the 5 largest Australian states for the period of 1995–2006. Time-series analyses found that increasing TRPs of tobacco control ads were significantly associated with decreasing monthly smoking prevalence; however, potential exposure to NRT ads showed no detectable effect on smoking prevalence.</p> <p>(Other studies in this category include: Cowling et al., 2010; Duke et al., 2014; Dunlop, Cotter, Perez, & Wakefield, 2013; Dunlop et al., 2012; Wakefield et al., 2014)</p>
TRP data aggregated across media markets *	<p>Farrelly, Nonnemaker, Davis, & Hussin (2009) examined the influence of media market delivery of “Truth” campaign TV commercials among adolescents in the US. They estimated cumulative TRPs for every study participant for each wave of the annual National Longitudinal Survey of Youth survey based on their media market of residence each year, and matched this potential exposure variable with the individual self-reported smoking initiation measures. They found that the total exposure to the “Truth” campaign was significantly associated with a decreased risk of smoking initiation.</p> <p>(Other studies in this category include: Emery et al., 2005; Farrelly, Davis, Duke, & Messeri, 2009; Farrelly, Davis, Haviland, Messeri, & Heaton, 2005; Wakefield et al., 2006; White, Durkin, Coomber, & Wakefield, 2013)</p>

* Note: For studies that belong to these two categories, almost all of them focused not merely on variation across media markets, but on media markets crossed with time as the unit of exposure assignment.

Table 3

Summary of POS Unobtrusive Observation Measure Categories and Examples

<i>Measure Categories</i>	<i>Description of Example Studies</i>
Community-based Observation	<p>Henriksen et al. (2008) unobtrusively collected the quantity of cigarette advertising in a random sample of stores (N =384) to get an average number of cigarette ads per school neighborhood, and combined this exposure data with self-reported smoking status data to examine the relationship between the density of tobacco retail advertising around schools and school smoking prevalence in California. They found that the average school smoking prevalence was significantly higher in neighborhoods with higher density of retail cigarette ads.</p> <p>(Other studies in this category include: Kim et al., 2013; Lovato, Hsu, Sabiston, Hadd, & Nykiforuk, 2007; S. J. Slater, Chaloupka, Wakefield, Johnston, & O'Malley, 2007)</p>
Individual-based Observation	<p>Kirchner et al. (2013) used geospatial tracking to continuously monitor and collect smokers' individual mobility patterns and overlaid this geospatial location data on a POS tobacco outlet geodatabase to estimate how much tobacco marketing exposure each individual might get according to his unique routes of travel on a daily basis. The outcome of interest – quitting status – was collected using ecological momentary assessment on cellular telephones, where they also self-reported real-time craving levels when queried by three random prompts per day. Their results suggested that, at individual level, lapsing was significantly more likely on days as the daily POS tobacco marketing exposure was higher.</p>

Table 4

Summary of Advertising Expenditures Measure Categories and Examples

<i>Measure Categories</i>	<i>Description of Example Studies</i>
Brand-specific commercial advertising	<p>Pollay et al. (1996) obtained nine brand-specific advertising expenditures for the years 1979–1993, and examined the relationship between the intensity of brand-level cigarette advertising and the realized brand market shares among adults and adolescents respectively. By estimating the impact of expenditure with a decaying pattern over time, the authors concluded that each 10% increase in the expenditure variable leads to 3% increase in the brand's adult market share and a 9.5% increase in brand share among teenagers.</p> <p>(Another study fits into this category is Gilpin & Pierce, 1997)</p>
Anti-tobacco campaign advertising	<p>Hu et al. (1995) examined the relationship between the California's quarterly antismoking media campaign expenditures, provided by California Department of Health Services, and per capita cigarette consumption for the years 1980–1993. They constructed quarterly depreciated state media campaign expenditure variable by accumulating media placement expenditures in all the past quarters, adjusted by a quarterly depreciation rate of 5%. The authors concluded that: the state media campaign had a significantly negative impact on per capita cigarette consumption.</p>

Table 5

Summary of Hybrid Measure Categories and Examples

Measure Categories	Description of Example Studies
Content analysis + Survey	<p>Sargent et al. (2001) coded tobacco occurrences for a pool of 601 popular movies that had been released between 1988 and 1999, and then they asked each adolescent in their sample which of a randomly-selected 50 movies they each had seen. With that data they were able to estimate each individual's total exposure to smoking in the larger sample of movies. They merged this potential exposure data with the prevalence of smoking initiation obtained from surveys. The study found a significant association between the level of exposure and the prevalence of ever trying a cigarette such that the prevalence was 31.3% for those who had seen more than 150 tobacco occurrences, compared to 4.9% for those who had only seen 0–50 occurrences.</p> <p>(Other studies in this category include: Arora et al., 2012; Avery, Kenkel, Lillard, & Mathios, 2006; Dalton et al., 2003, 2009; Distefan, Pierce, & Gilpin, 2004; Dunlop, Cotter, & Perez, 2014, p. 2014; Hanewinkel, Morgenstern, Tanski, & Sargent, 2008; Hanewinkel & Sargent, 2007, 2008; Hunt et al., 2009; Hunt, Henderson, Wight, & Sargent, 2011; Morgenstern et al., 2011, 2013; Nagelhout, van den Putte, de Vries, & Willemsen, 2011; Primack et al., 2012; Sargent et al., 2002, 2005, 2007; Sargent, Gibson, & Heatherton, 2009; Sargent & Hanewinkel, 2009; Song, Ling, Neilands, & Glantz, 2007; Tanski, Stoolmiller, Gerrard, & Sargent, 2012; Thrasher et al., 2009, 2008; Tickle, Sargent, Dalton, Beach, & Heatherton, 2001; Titus-Ernstoff, Dalton, Adachi-Mejia, Longacre, & Beach, 2008; Waylen, Leary, Ness, Tanski, & Sargent, 2011; Wilkinson et al., 2009)</p>
GRP + Survey	<p>Hyland, Wakefield, Higbee, Szczypka, & Cummings (2006) complemented market-level GRPs reflecting exposure to state-sponsored anti-tobacco advertising with self-reported responses that captured individual differences in perception of available information. Their outcome was smoking cessation rates. The results confirmed their hypotheses that increased GRPs for state anti-tobacco media is significantly associated with increased smoking cessation rates, and that the association was larger among the participants who reported “a lot” of increase in the amount of information in the media about the dangers of smoking.</p> <p>(Another study in this category is Hwang, 2012, <i>which explored both individual and social paths of effect for campaign influence on smoking related beliefs within a multi-level modeling framework</i>)</p>
Unobtrusive observation + Survey	<p>Feighery, Henriksen, Wang, Schleicher, & Fortmann (2006) developed a hybrid exposure measure by combining self-reported mobility patterns and unobtrusively recorded POS tobacco brand marketing data to examine how such exposure related to the odds of ever smoking and susceptibility to smoke among adolescents. They calculated cigarette brand impressions by multiplying total number of cigarette ads in each store, which was obtained via direct store observations, and the self-reported frequency of visits to these stores for each respondent. The study concluded that this hybrid estimation of POS tobacco marketing exposure is significantly and positively associated with both the odds of ever smoking and susceptibility to smoking.</p> <p>(Another study in this category is Henriksen, Schleicher, Feighery, & Fortmann, 2010)</p>
Ads expenditure + Survey	<p>Dave & Saffer (2013) combined information about individual reading habits with regard to 198 major magazines, which was indicative of the respondent's probability of reading an article in each magazine, and the expenditures per reader on smokeless tobacco (ST) ads that appeared in each magazine to quantify the potential exposure to ST ads for each individual. They associated this hybrid exposure variable with the survey measure of ST use, and detected robust evidence that higher exposure to ST advertisements in magazines is associated with higher ST use, especially among males.</p>