RESEARCH ARTICLE

Evaluation of a Skin Self-Examination Programme: a Four-Stage Recursive Model

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Abstract

Background: Effective skin self-examination can enable early diagnosis and treatment of skin cancer, which otherwise could result in significant morbidity and mortality. We compare the effects of watching a DVD and reading printed materials on self skin examination. **Methods:** Longitudinal data from the Randomized Skin Awareness Trial were analysed (n=984). The control group were provided with written materials describing how to conduct effective skin self-examination. The intervention group received additional instruction from a DVD. It was hypothesized that self skin examination may be confounded by unobserved variables. A recursive model was specified to control for this potential source of bias. **Results:** At six months only watching the DVD had a statistically significant effect on diagnosed skin cancer. By 12 months both interventions were statistically significant; reading the printed materials was 63% as effective as watching the DVD. **Conclusion:** Watching a DVD was associated with the largest increase in diagnosed skin cancer. However, reading written materials was also associated with an increase in diagnosed skin cancer. Both visual and written communication should be considered when designing an effective skin self-examination programme.

Keywords: Skin cancer screening- endogeneity- self skin-examination- recursive model

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Introduction

The purpose of screening for disease is to reduce the time between when asymptomatic disease is theoretically detectable and clinically diagnosed, (Gyrd-Hansen et al., 1997) enabling treatment to commence earlier. Skin self-examination for skin cancer can be effective because non-clinicians can identify potentially malignant lesions, skin cancers can readily treated with wide excision and public education can be targeted (Stratigos and Katsambas, 2009). Despite the potential benefit, evidence of effective skin self-examination and clinical examination remains uncertain, and so it is important to better understand how to motivate people to undertake these examinations.

Glanz et al., (2005) have stated that real-world diffusion studies are necessary to learn about the effectiveness of skin cancer prevention programs in less controlled conditions. The effectiveness of skin self-examination is influenced by information delivery. Youl et al. (2005) report that personalized letter was more effective than a generic brochure to encourage presentation for a clinical skin examination, while Janda et al., (2011) report that the addition of a video to written materials had only a transient effect on skin checking behavior of men over the age of 50 years.

In 2007, the randomised Skin Awareness Trial was initiated to assess the impact of a video-based educational intervention on the prevalence of skin self-examination and clinical examination outcomes in a population of men older than 50 years of age (Janda et al., 2009; Janda et al., 2011; Janda et al., 2013). In the trial design, printed educational material was distributed to all participants and DVDs were distributed to the intervention group only (Janda et al., 2011). The primary analysis sought to investigate what effect that receiving the DVD had on reported skin self-examination compared with receipt of the printed material only. However, the analysis did not compare the effectiveness of these two methods.

In this paper, our aim is to compare the efficacy of DVD with printed materials in initiating a skin self-examination and skin cancer diagnosed. Failure to address uncontrolled confounding has been identified as a limitation in research that has analysed skin self-examination on clinical outcomes (Baade et al., 2006; Olsen et al., 2015). Ignoring unobserved heterogeneity in this patient population may produce biased empirical estimates. Individuals with a history of skin cancer are twice as likely to initiate a clinical skin examination than individuals with no previous history (Olsen et al., 2015). In the analysis that follows, we estimate a recursive system to control for unobserved heterogeneity in our data.

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Materials and Methods

A random sample of 2,899 men aged over 50 years who were residents of the state of Queensland were selected from the Australian Electoral Roll (enrolling to vote is compulsory in Australia). Men received letters of invitation and a brochure, which they could return to the study team with their written informed consent. As data was collected by telephone interviews, men were considered ineligible if they had a disconnected telephone line, were too ill, could not speak English, or had previously had a melanoma. The overall consent rate was 37% (969 of 2610 eligible); however, 39 men withdrew before the study began, leaving a final sample of 930. Of these 930 participants recruited, 469 were randomised into the intervention group and 460 into the control group by computer-generated random number list, stratified by men's region of residence (metropolitan or other). Members of the control group were provided with written materials describing how to conduct skin self-examination. Those in the intervention group received: (i) a 12-minute DVD reiterating the information contained within the written materials; (ii) a body chart to facilitate an effective skin self-examination; and (iii) reminder postcards at 2 and 4 weeks after the initial intervention (Janda et al., 2011).

Participants were asked to complete computer-assisted telephone interviews conducted by a professional survey company not otherwise involved in the study at baseline, six months and 12 months after recruitment. Information was collected about demographic factors (age, marital status, place of birth, residence, educational status and occupation) and skin cancer risk factors (skin phenotype, exposure to sunlight and sun protective behaviours). Consent was obtained for general practitioners to release clinical information (Janda et al., 2009), which enabled histological results of excised skin lesions to be acquired (data not reported here) (Janda et al., 2013). Outcome measures included whether or not the participant reported reading or watching the educational materials provided or performing skin self-examination (Janda et al., 2011), or observed any moles on their skin. Participating general practitioners (GPs) reported if the participant presented for a clinical exam and the histological results emanating from any skin biopsies taken.

An individual's propensity to initiate a skin self-examination may be affected by unobserved factors, which, if correlated with skin self-examination, could bias the results. For example, private information about an individual's exposure to UV light may not be fully captured by the data. This property can result in a bi-directional relationship; individuals with skin cancer are observed to engage in more skin self-examination, and individuals who engage in more skin self-examination identify more skin cancer. Explanatory variables, which have a bi-directional relationship with the dependent variable, are also referred to as endogenous.

We therefore specified a recursive system of equations, which exploits the unidirectional causal pathway identified in Figure 1. The identification progression from unidentified to an identified skin cancer is assumed to move through four discrete stages. First, watching DVD or reading printed materials, may encourage individuals to initiate a skin self-examination. Second, the skin self-examination may identify an abnormal skin lesion, which we henceforth refer to as a "mole". Third, identification of a mole may precipitate an appointment with a general practitioner or skin specialist for further investigation. Fourth, a clinical skin examination may confirm diagnosis of a skin cancer, which was defined as melanoma, squamous cell cancer or basal cell cancer.

The recursive system of equations (eq.1-eq.8) exploits this unidirectional dependency among the endogenous variables such that, for given a set of exogenous variables, the endogenous variables can be identified sequentially (Cortina, 2005).

Recursive Model

$$SSE_6 = f(DVD_6, PM_6, MO_0, SC_0, SSE_0, HS_0, M_0, SF_0, OO_0, \mathbf{B}_0, \mathbf{B}_6) \quad \text{eq. (1)}$$
$$MO_6 = f(SSE_6, MO_0, SC_0, \mathbf{B}_0, \mathbf{B}_6) \quad \text{eq. (2)}$$
$$CSE_6 = f(MO_6, VGP_0, DGP_0) \quad \text{eq. (3)}$$
$$SCC_6 = f(CSE_6, SC_0) \quad \text{eq. (4)}$$
$$SSE_{12} = f(DVD_{12}, PM_{12}, MO_6, SC_6, SSE_0, HS_0, M_0, SF_0, OO_0, \mathbf{B}_0, \mathbf{B}_{12}) \quad \text{eq. (5)}$$
$$MO_{12} = f(SSE_{12}, DVD_{12}, SC_0, \mathbf{B}_0, \mathbf{B}_{12}) \quad \text{eq. (6)}$$
$$CSE_{12} = f(MO_{12}, VGP_0, DGP_0) \quad \text{eq. (7)}$$
$$SCC_{12} = f(CSE_{12}, SC_0) \quad \text{eq. (8)}$$

Where

SSE	= 1 if conducted a skin self-examination for skin cancer & = 0 if otherwise
MO	= 1 if suspect mole observed & = 0 if otherwise
CSE	= 1 if attended a clinical skin examination & = 0 if otherwise
SCC	= Skin cancer count confirmed by pathology
DVD	= 1 if watched DVD & = 0 if otherwise
PM	= 1 if read printed materials & = 0 if otherwise
SC	= 1 if history skin cancer & = 0 if otherwise
SF	= 1 if skin fair or very fair & = 0 if medium or olive
OO	= 1 if occupation outdoors & = 0 if otherwise
HS	= 1 if completed high school & = 0 if otherwise
M	= 1 if married or living together & = 0 if otherwise
VGP	= 1 if regularly visit your GP for health check-ups, & = 0 if otherwise
DGP	= Distance from home to GP or health care provider (km)
B	= PCA of the behaviours (i) Wears shirt, (ii) Wears sunglasses (iii) Stays shady (iv) Uses sunscreen (v) Limits time in sun (vi) Wears hat & (vii) Uses umbrella
Subscript	= 0, 6 & 12 months

Equations 1 to 4 recursively estimate skin self-examination (eq. 1), moles observed (eq. 2), clinical skin examination (eq. 3) and count of SCs (eq. 4) at six months. Equations 5 to 8 repeat the recursive estimation process at 12 months. In equations, 1 and 5 the explanatory variables of interest are binary controls for watched DVD and read printed materials. Two vectors of covariates are included, which we hypothesise may affect skin self-examination. The first, is a vector of time invariant individual characterises including binary controls for history of skin cancer, moles observed, skin phenotype (skin fair or very fair) , and demographic characteristics including completed high school or married.

The second, $\mathbf{B}_{it}$ is a vector of time variant sun protective behaviours, which are hypothesised to affect the incidence of skin cancer and/or skin self-examination. These include, (i) wears a shirt, (ii) wears sunglasses, (iii) stays shady, (iv) uses sunscreen, (v) limits time in sun, (vi) wears a hat and (vii) uses an umbrella. Figure A 2 reports the prevalence of these behaviours at baseline, six and 12 months. Controls for sun protective behaviours were developed using principal component analysis (PCA). This method is a data reduction technique, which has a wide range

of applications in psychology, biology, anthropology, economics and finance. PCA captures the variance of data by constructing a small number of variables (called principal components) using linear combinations. The use of PCA is effective in capturing some specific data dimensions, and a large number of variables can reduce to a few when the original data is highly correlated. The subscripts *i* and *t* denote the individual and time period, respectively.

In equations, 2 and 6 the dependent variable is a binary measure of moles observed. The time invariant explanatory variables included co-variates for history of skin cancer, skin phenotype (skin burns and skin fair) and four co-variates for UV exposure (age, latitude, occupation outdoors and born in Australia). A vector of time variant behaviours $\mathbf{B}_{it}$ is again included. In equations 3 and 7, the dependent variable is a dichotomous measure clinical skin exam. The explanatory variables were moles observed and proximity to a GP (visits GP and distance to GP).

Results

Figure 2 summarises the responses to the Randomised Skin Awareness Trial (Janda et al., 2009) at baseline, six and 12 months. The uptake of both the DVD and the printed materials showed an increase at six months before tapering slightly at 12 months. In response skin self-examination increased over the duration of the study. The number of respondents who self-reported moles at six months increased substantially before declining slightly at 12. The over-all trend was increasing. On balance, the number of clinical examinations remained largely unchanged over the 12 months. At baseline, 660 respondents indicated they had been previously been diagnosed with a skin cancer. The number of newly diagnosed SCs at six and 12 months was 44 and 39, respectively.

Table 1 reports our empirical results. In each equation, the dependent variable is shaded in dark grey and the explanatory variable primary interest is shaded in light grey. There are two results of principal interest. Firstly, watching the DVD had the greater and more instantaneous impact on skin self-exam. At six months only watched DVD (0.25 p=0.07) was correlated with skin self-exam. However, by 12 months watched DVD (0.35 p=0.03) and read PM (0.22 p=0.05) were both positively correlated with skin self-exam. Secondly, all the key explanatory variables were statistically significant at each stage of the recursive model. At six months, skin self-examination was positively correlated with observes suspect mole, which was positively correlated with clinical skin exam, which was positively correlated with skin cancer. Statistically significant correlations were also observable at 12 months. This offers *prima facie* evidence that the increased skin self-examination attributed to the intervention in equations 1 and 5 resulted in an increase in skin cancer diagnosed in equations 4 and 8.

Controlling for observed and unobserved individual characteristics gives the coefficients for PM and DVD in equations (1) and (5) a "causal" interpretation. Hence,

SSE → Mole → CSE → SC

Figure 1. The Identification Progression for a Skin Cancer,

ceteris paribus, we can report that at 12 months, reading the printed matter had approximately 63% [i.e., (0.22/0.35) x 100] of the effect that watching the DVD had on skin self-examination and skin cancer diagnosed.

The coefficients for covariates indicate some important behavioural changes. Comparing the results from equations 1 and 5, we see, at six months, fair or very fair skin was not correlated with skin self-examination (equation 1.) but by 12 months, it was correlated (0.36 p<0.01) with such behaviour. Similarly, sun protective behaviours undertaken at six months were not correlated with skin self-examination, but by 12 months, sun protective behaviour at 12 months was significantly correlated (0.13 p=0.05) with skin self-examination. These changes is consistent with evidence of learning. In the results from equations 2 and 6, we observe that sun protective behaviours remained correlated with the identification of suspect moles at 6 months (0.14 p=0.01) and 12 months (0.08 p=0.05) and in the results from equations 3 and 7, visits GP was correlated with a clinical skin exam.

Discussion

The principal aim was to differentiate the effect that watching the DVD and reading the printed materials had on skin self-examination behaviours and skin cancers diagnosed. The key explanatory variables from the identification progression (SSE, MO and CSE) were statistically significant at each stage of the recursive model. This confirms that increased skin self-examination did result in increased skin cancer diagnosed.

Watching the DVD had a larger and immediate impact on skin checking behaviour than reading the printed material alone. However, by 12 months reading the printed

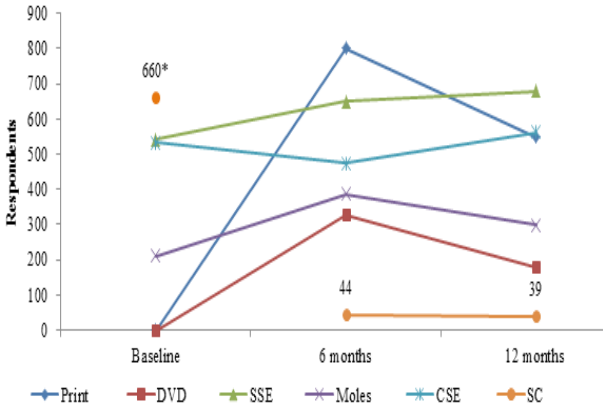

Figure 2. Respondents to the Randomised Skin Awareness Trial at Baseline, Six and 12 Months.
Note, * At baseline, 660 respondents self-reported they previously had a skin cancer, spot or mole removed. This statistics is not directly comparable to numbers of respondents who were newly diagnosed with skin cancer at six and12 months.

Table 1. Regression Results from the Recursive Model

	Coefficient		Coefficient
Equation 1		Equation 5	
Skin Self-Exam_6 (SSE_6) (0/1)		Skin Self-Exam_12 (SSE_12) (0/1)	
Watched DVD _6 (0/1)	0.25*	Watched DVD _12 (0/1)	0.35**
Read print _6 (0/1)	0.08	Read print _12 (0/1)	0.22*
Skin Cancer_0 (0/1)	0.22	Skin Cancer_6 (0/1)	0.16
Moles observed_0 (0/1)	0.26	Moles observed _6 (0/1)	0.24*
Skin self-exam_0 (0/1)	0.33*	Skin self-exam_6 (0/1)	1.16***
Completed High School (0/1)	0.12	Completed High School (0/1)	-0.18
Married (0/1)	0.19	Married (0/1)	0.04
Skin fair or very fair (0/1)	≈ 0	Skin fair or very fair (0/1)	0.36***
Occupation outdoors (0/1)	0.1	Occupation outdoors (0/1)	≈ 0
Sun protective behaviour_0	0.09	Sun protective behaviour_0	-0.06
Sun protective behaviour_6	0.04	Sun protective behaviour_12	0.13**
Constant	0.04	Constant	-0.31
Equation 2		Equation 6	
Observed Moles_6 (0/1)		Observes Moles_12 (0/1)	
Skin self-exam _6 (0/1)	0.5***	Skin self-exam _12 (0/1)	0.54**
Moles observed_ 0 (0/1)	0.48***	Moles observed _6 (0/1)	0.34**
Skin Cancer_0 (0/1)	0.75***	Skin Cancer_6 (0/1)	0.21
Sun protective behaviour_0	0.14***	Sun protective behaviour_0	0.08**
Sun protective behaviour_6	-0.03	Sun protective behaviour_12	-0.01
Constant	0.08	Constant	0.17
Equation 3		Equation 7	
Clinical Skin Exam _6 (0/1)		Clinical Skin Exam _12 (0/1)	
Moles observed_6 (0/1)	0.43***	Observes moles_12 (0/1)	0.58***
Visits GP (0/1)	0.17**	Visits GP (0/1)	0.11*
Distance to GP (km)	≈ 0	Distance to GP (km)	≈ 0
Constant	-0.51***	Constant	-0.25**
Equation 4		Equation 8	
Skin Cancer_6		Skin Cancer_12	
Clinical skin exam _6 (0/1)	1.35***	Clinical skin exam _12 (0/1)	1.49***
Skin Cancer_0 (0/1)	0.34**	Skin Cancer_6 (0/1)	0.23
Constant	-2.07***	Constant	-2.12***

Note; (i) Underscores _0, _6 and _12 denote baseline, six months and 12 months, respectively.
(ii) The level of statistical significance are denoted by *** at 1%, ** at 5% and * at 10%

materials had also made a significant contribution to the public health benefit; 63% of the impact of watching the DVD. These results suggest that while advancements in information technology may have increased the ways in which visual data can be communicated to the public (e.g., internet, smart phones and telehealth); printed materials should not be over-looked as an effective conduit for skin self-examination campaigns for men over the age of 50 years.

There is a recognized need to better understand the delivery skin cancer prevention programmes in the community setting (Glanz et al., 2005). Although, the effectiveness of personalise written materials (Youl et al., 2005) and video (Janda et al., 2011) have been studied previously, the efficacy of the two strategies has not been compared in a community setting. Bias due to uncontrolled confounding factors has been recognised as a limitation in analyses of skin self-examination programmes (Baade et al., 2006; Olsen et al., 2015). In this study, we utilize a recursive model to control for unobserved confounding factors that are correlated with skin self-examination, which other researchers may wish to consider.

Our analysis also provides some important -albeit rudimentary- insights into the dynamics of a skin self-examination programme directed at the public. A comprehensive skin cancer campaign should not only result in an increase in skin self-examination but also a concordant increase in sun protective behaviours, thus ensuring timely treatment of current skin cancer and prevention of future skin cancer. The coefficients of covariates reported in Table 1 provide some corroborating evidence of such learning and sun protection behavioural

changes in the target population. At six months, fair or very fair skin and sun protective behaviour was not correlated with skin self-examination but by 12 months, they were correlated. These behavioural changes are encouraging, and if maintained, could result in reductions in future skin cancers. However, further research would be required to establish the magnitude and maintenance of these behavioural changes.

Although our data included a rich array of information including, skin phenotype, demographic details, and behavioural characteristics, we were unable to analyse the impact of the SSE programme on diagnosed melanoma due to the small size and duration of our panel. Skin self-examination has been reported to increase melanoma diagnosis in selected patient samples, (Berwick et al., 1996; Carli et al., 2003; Aitken et al., 2004; Williams et al., 2011; Quereux et al., 2012; Badertscher et al., 2014). Public health initiatives that have promoted skin self-examination in Australian (Janda et al., 2009), Italian (Rossi et al., 2000), Greek (Stratigos et al., 2007) and German (Waldmann et al., 2012) populations, have also reported increased numbers of CM diagnosed., however, the results from a British study were inconclusive (Melia, 1995; Melia et al., 1995; Melia et al., 2000). Analysis with longitudinal data, could potentially reveal both the short-run and long run effects of SSE programmes not reported in these analyses. We suggest that other researchers, who may be interested in the empirical evaluation of skin self-examination programmes may consider analysis of longitudinal data, with a recursive model, to control for bias due to unobserved confounding in this patient population.

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