An evaluation of a skin self-examination programme: Four-stage recursive model

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Asian Pacific Journal of Cancer Prevention

ABSTRACT:

Background: Effective skin self-examination can enable the early diagnosis and treatment of skin cancer, which otherwise could result in significant morbidity and mortality. We compare the effect of watching a DVD and reading printed materials had 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 also 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 DVD.

Conclusion: Watching a DVD was associated with 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.

Key words: Skin cancer screening, Endogeneity, Self skin-examination, Recursive model
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.

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). Of the 930 participants recruited, 469 were randomised into the intervention group and 460 into the control group. 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 surveys 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 not fully captured in 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.

![Figure 1: The Identification Progression for a Skin Cancer](image)

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

**Recursive Model**

\[
\begin{align*}
\text{SSE}_6 &= f(\text{DVD}_6, \text{PM}_6, \text{MO}_0, \text{SC}_0, \text{SSE}_0, \text{HS}_0, M_0, \text{SF}_0, \text{OO}_0, B_0, B_6) \\
\text{MO}_6 &= f(\text{SSE}_6, \text{MO}_0, \text{SC}_0, B_0, B_6) \\
\text{CSE}_6 &= f(\text{MO}_6, \text{VGP}_0, \text{DGP}_0) \\
\text{SCC}_6 &= f(\text{CSE}_6, \text{SC}_0) \\
\text{SSE}_{12} &= f(\text{DVD}_{12}, \text{PM}_{12}, \text{MO}_6, \text{SC}_6, \text{SSE}_0, \text{HS}_0, M_0, \text{SF}_0, \text{OO}_0, B_0, B_{12}) \\
\text{MO}_{12} &= f(\text{SSE}_{12}, \text{DVD}_{12}, \text{SC}_0, B_0, B_{12}) \\
\text{CSE}_{12} &= f(\text{MO}_{12}, \text{VGP}_0, \text{DGP}_0) \\
\text{SCC}_{12} &= f(\text{CSE}_{12}, \text{SC}_0)
\end{align*}
\]

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

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. $I_i$ 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.

$B_{it}$ 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.1 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. Variable definitions are provided in Appendix A.

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 & skin fair) and four co-variates for UV exposure (age, latitude, occupation outdoors and born in Australia). A vector of time variant behaviours $B_{it}$ 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.

![Graph showing respondents to the Randomised Skin Awareness Trial at baseline, six and 12 months](image)

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 and 12 months.

Figure 2: Respondents to the Randomised Skin Awareness Trial at baseline, six and 12 months

Table 1, reports our empirical results. The key explanatory variables were statistically significant at each stage of the recursive model. At six and 12 months, *skin self-examination* was positively correlated with *observes suspect mole*, which was in turn positively correlated with a *clinical skin exam* and *clinical skin exam* was positively correlated with diagnosed *skin cancer*. The results confirm that watching the DVD had a greater impact on skin cancer diagnosed than reading the printed materials. *Watched DVD* was positively correlated with *skin self-exam* at both six months (0.25 p=0.07) and 12 months (0.35 p=0.03). While *read print* was not correlated with *skin self-examination* at six months (0.08 p=0.76), by 12 months *read print* was correlated with a *skin self-examination* (0.22 p=0.05). In principle, controlling for observed and unobserved individual characteristics gives the coefficients for *PM* and *DVD* in equations (1) and (5) a “causal” interpretation. Hence, *ceteris paribus*, we can report that at 12 months, reading the printed matter had approximately 63% [i.e., (0.22/0.35)100] of the effect that watching the DVD had on skin self-examination and skin cancer diagnosed.

Table 1: Regression Results from the Recursive Model
Skin Self-Exam_6 (SSE_6) (0/1) | Coefficient | Skin Self-Exam_12 (SSE_12) (0/1) | Coefficient
---|---|---|---
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

**Observed Moles_6 (0/1)**

| Coefficient | Observed Moles_12 (0/1) | Coefficient
---|---|---
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

**Clinical Skin Exam_6 (0/1)**

| Coefficient | Clinical Skin Exam_12 (0/1) | Coefficient
---|---|---
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**

**Skin Cancer_6**

| Coefficient | Skin Cancer_12 | Coefficient
---|---|---
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%

**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 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.

A secondary goal was to explore the feasibility of specifying a recursive model to control for any unobserved confounding factors that maybe correlated with skin self-examination. The identification progression for a skin cancer embodies a unidirectional linear process (see Figure 1) which enabled a recursive model to be specified. Our data set included a rich array of information including, skin phenotype, demographic details, and behavioural characteristics, reported over three time points, which were included in our model. However, due to the small number of skin cancers identified and relatively short period of follow up, we did not attempt to draw concrete conclusions about the effects size that watching the DVD or reading the printed materials had on men’s clinical outcomes and additional skin cancer diagnosed. In principle, an analysis of this type may be possible if a larger data set was available.

Nevertheless, our analysis of the longitudinal data offers 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 was not correlated with skin self-examination but by 12 months, it was correlated with such behaviour. Similarly, sun protective behaviours undertaken at six months were not correlated skin self-examination, but by 12 months, these behaviours were significantly correlated. These behavioural changes are encouraging, and if maintained, could result in reductions in future skin cancers. Further research would be required to establish the magnitude and maintenance of these behavioural changes.

ACKNOWLEDGMENT:

This trial was funded by the Australian National Health and Medical Research Committee (NHMRC) project grant 497200; Monika Janda is supported by a NHMRC Career development Award 553034.
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