**Appendix**

By using different random variables, we can avoid the assumption of GW that dropping out is independent of the prior history of false positives. Lt $R_{tx} = 1$ if a subject with covariates at level $x$ had $t$ screenings and 0 otherwise. Because the only missingness is dropouts, $pr(R_{tx} = 0 \,|\, R_{(t-1)x} = 0) = 1.$ Let $Y_{tx} = 1$ if a subject with covariates at level $x$ would have had a false positive *if* the subject received the $t^{th}$ screening and $Y_{tx} = 0$ if the result would not have been a false positive. Importantly, $Y_{tx}$ (with realization $y_{tx}$) is a *potential outcome* that is present regardless of whether or not a subject is screened.

We assume the probability of receiving the $t^{th}$screening depends on whether or not there was a previous screening, $r_{t-1}$, and the FP history up to and including the outcome on screening number $(t-1)$, namely, $y_1, y_2, ...., y_{t-1}$. Without loss of generality we describe the model for three screenings. Extensions to more screenings, such as the four screenings in our application, are straightforward. Let $\phi$ denote a vector of parameters modeling the distribution of $Y_1, Y_2, ...., Y_{t-1},\ Y_t$. Under the assumed dropout mechanism, the probability of receiving only one screening with outcome $y_{1x}$ is

$$pr(R_{2x} = 0|\, R_{1x} = 1, y_{1x})\, pr(R_{1x} = 1) \quad pr(y_{1x};\, \phi),$$

the probability of receiving exactly two screenings with outcomes $y_{1x}$and $y_{2x}$ is

$$pr(R_{3x} = 0|\, R_{2x} = 1,\, y_{1x}, y_{2x})\, pr(R_{2x} = 1|\, R_{1x} = 1, y_{1x}) \quad pr(R_{1x} = 1)$$
$$pr(y_{1x}\,, y_{2x};\, \phi),$$

and the probability of receiving exactly three screenings with outcomes $y_{1x}$ , $y_{2x}$ and $y_{3x}$ is

$$pr(R_{4x} = 0|\, R_{3x} = 1, y_{1x}, y_{2x},\, y_{3x}) \quad pr(R_{3x} = 1|\, R_{2x} = 1, y_{1x}, y_{2x})$$

$pr(R_{2x} = 1|\, R_{1x} = 1, y_{1x})\ pr(R_{1x} = 1)\ pr(y_{1x}, y_{2x}, y_{3x};\, \phi).$

We use the above probabilities to formulate a likelihood. The key observation which obviates the unrealistic dropout assumption in GW is that the likelihood for the parameters $\phi$ modeling the outcomes can be factored from the part of the likelihood modeling the dropout mechanism..

Let $n_1(y_{1x})$ denote the number of subjects screened exactly once with outcome $y_{1x}$. Let $n_2(y_{1x}, y_{2x})$ denote the number of subjects screened exactly twice with outcomes $y_{1x}$and $y_{2x}$. Similarly, let $n_3(y_{1x}, y_{2x,}y_{3x})$ denote the number of subjects screened exactly three times with outcomes $y_{1x},\ y_{x2}$ and $y_{3x}$. The part of the likelihood involving parameters modeling the false positive rate is

$$L_1 = \prod_{y_{1x=0}}^{1} \prod_{y_{2x=0}}^{1} \prod_{y_{3x=0}}^{1} pr(y_{1x};\, \phi)^{n_1(y_{1x})}\ [pr(y_{2x}|y_{1x}; \phi)\, pr(y_{1x}; \phi)\,]^{n_2(y_{1x}, y_{2x})}$$
$$[pr(y_{3x}|y_{1x},\ y_{2x};\ \phi) pr(y_{2x}|y_{1x}; \phi)\ pr(y_{1x}; \phi)]^{\,n_3(y_{1x}, y_{2x,} y_{3x})}\,. \qquad \text{(A.1)}$$

It is helpful to regroup the factors in (A.1) as

$$L_1 = \prod_{y_{1x}=0}^{1} pr(y_{1x};\, \phi)^{n_1(y_{1x}) + n_2(y_{1x},+) +\ n_3(y_{1x},+,+)}$$
$$\prod_{y_{1x=0}}^{1} \prod_{y_{2x=0}}^{1} pr(y_{2x}\ |\ y_{1x}; \phi)^{\,n_2(y_{1x}, y_{2x}) +\ n_3(y_{1x}, y_{2x,}+)}$$
$$\prod_{y_{1x=0}}^{1} \prod_{y_{2x=0}}^{1} \prod_{y_{3x=0}}^{1} pr(y_{3x}|y_{1x},\ y_{2x};\ \phi)^{n_3(y_{1x}, y_{2x,} y_{3x})}. \qquad \text{(A.2)}$$

where "+ " denotes summation over the indicated variable.

To incorporate covariates, we modify the likelihood in (A.2). Let $i$ index age at screening and $j$ index time since the last screening. There are too few data to adequately fit a model that conditions on various prior patterns of FP. Instead, we simply condition on whether an FP occurred previously ($k = 1$) not ($k = 0$). Thus instead of $x$ we have covariates indexed by $i, j, k$.

Because we condition on whether or not an FP occurred previously (so a first screening if fundamentally different from a subsequent screening in predicting an FP), it is convenient to change the notation and specify distinct parameters for first screening, $\alpha$, and subsequent screening, $\beta$. We write

$$pr(Y_{1x} = y;\, \phi) = pr(Y_{1i} = y;\, \alpha)$$

$$pr(Y_{tx} = y | y_{1x}, ... y_{(t-1)x};\, \phi) = pr(Y_{tij} = y |\text{ previous history };\, \beta)$$

$$= pr(Y_{tijk} = y;\, \beta),$$

where the relevant previous history under the model is captured by $k$.

Let $m_{1yi}$ denote the number of subjects on the first screening in age interval $i$ who had FP outcome $y$. Let $m_{tyijk}$ denote the number of subjects on screening $t$ in age interval $i$ with time interval $j$ since the last screening and false positive category $k$ who had FP outcome $y$. Under this formulation we write the likelihood in (A.2) with $n$ screenings as

$$L_2 = \prod_i \prod_{y=0}^{1} pr(Y_{1\mathrm{i}} = y;\, \alpha)^{m_{1yi}} \prod_i \prod_j \prod_k \prod_{t=2}^{n} \prod_{y=0}^{1} pr(Y_{tijk} = y;\, \beta)^{m_{tyijk}}. \tag{A.3}$$

The logistic regressions in the text are based on (A.3).