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Supplementary Material

The financial implications of investigating false-positive and true-positive mammograms in a national breast cancer screening program

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Supplement – Additional methodological notes

1. Costing of diagnostic open biopsies and its treatment as a cost to the public hospital system

Almost 0.1% of patients in our sample were assessed with atypical ductal hyperplasia (ADH) and had 'diagnostic open biopsy' in their final assessment recommendation field with no further indication of whether they were false positive or true positive. Rather than exclude this group of patients, for costing purposes we assumed that the share of false positives in this group was similar to the share of false positives expressed as a percentage of total assessed clients who were not assessed with ADH and therefore were not assigned to a diagnostic open biopsy, and the share of true positives was similar to the share of true positives expressed as a percentage of total assessed clients who were not assessed with ADH and therefore were not assigned to a diagnostic open biopsy.

Diagnostic open biopsy is a procedure undertaken in hospital rather than in the BreastScreen facility. We do not know what share, if any, of this tiny minority of patients might have sought to expedite their testing by seeking private hospital treatment rather than public hospital treatment. If any of these patients had sought private treatment, then some share of them might also incur expenses 'out of pocket' if their private health insurance does not sufficiently cover the cost of this procedure in a private hospital. Rather than adopt additional complicated assumptions for this small subset of patients, we made the simplifying assumption that all patients recommended for a DOB obtained one in a public hospital (therefore 'free' at point of delivery) so that the cost incurred for this is another public-system incurred cost.

2. Share of total breast-cancer screening which is private screening

The estimate of 26% of total breast screening in Australia being through private screening is based on adding up the number of women screened in 2016 by BreastScreen Australia (from **eTable 1**) as reported in Table S4.11 of AIHW (2019)[1] and the number of women undergoing Medicare Benefits Schedule (MBS) subsidised breast mammograms under item 59300 (mammography of both breasts) in 2016 and then calculating the number of women undergoing Medicare-subsidised breast mammograms in 2016 as a percentage of this total. The MBS is a list of the medical services for which the Australian Government will pay a Medicare rebate, to provide patients with financial assistance towards the costs of private medical services. Thus, if a patient chooses to use a private provider and then claims a MBS rebate to recoup the costs of the private service, data on the usage of the private service can be captured. We note a number of caveats associated with this estimate:

- The private mammograms undertaken in this context may be for the purpose of investigating breast symptoms, for surveillance of women at high risk of developing breast cancer or for surveillance of women who have a personal history of breast cancers. It is unclear what percentage of women undergoing these private mammograms would be doing so as an alternative to and in complete substitution of undergoing screening through a BreastCancer Australian service.
- At the same time, MBS data are not able to capture all mammography that occurs outside BreastScreen Australia because some women may choose to access private screening mammography on a full user-pays basis, for which a MBS rebate cannot be claimed.

While the second caveat may lead to an underestimate of the use of private screening services, the first caveat may be more significant in leading to an overestimate as it is unclear how many women are claiming MBS rebates for private screening in cases where these are supplementary to rather than in substitution of of services provided by BreastScreen Australia. It is only in the latter case that these services would count towards the share of total screening which is undertaken through private screening. We note that our approach is also likely to be an overestimate (and therefore in that respect resulting in a more conservative estimate of the share of breast screening undertaken through BreastScreen Australia) compared to the approach taken in the 2009 BreastScreen Australia Evaluation Report[1]which after a series of exclusions (which we were not able to replicate because we did not request more customised MBS data), estimated that 45% of bilateral mammograms in women aged 40+ in 2006 were diagnostic (therefore not for screening purposes), leaving an estimated 23% which were non diagnostic and 32% 'unknown'. Assuming for simplicity that the bilateral mammograms for 'unknown' purposes are also for 'non-diagnostic' purposes, and therefore assuming that 55% of MBS-funded bilateral mammograms under item 59300 were for screening purposes in 2016 would give us an estimate of approximately 14.5% of breast screening being through private services (if we included only services provided to women aged 35 years and over).

[1] Evaluation of the BreastScreen Australia Program – Evaluation Final Report – June 2009.

3. Caveats to inclusions

Within the included sample 0.05% were recalled to assessment and then classified under ‘routine recall’ as a final recommendation in 2016 but their discharge fields were subsequently updated to account for breast cancer being detected after. Thus technically these clients fell under our working definition of a ‘false-positive’ (women recalled for assessment who ultimately received a ‘routine recall’ recommendation). Possible alternatives for classifying these cases would have been to (i) classify them as false-positive cases as they fall within the definition; (ii). exclude them from consideration altogether or (iii) treat them as neither false positives nor false negatives but classify them as ‘miscellaneous’ because they were found to be positive after 2016. For simplicity we have adopted the first approach.

4. Additional tables

Table S1 summarises some key national indicators from 2016 data that we used as the basis for extrapolating the results of our sample analysis to a national scale.

Table S1: Key national indicators from BreastScreen Australia data for 2016[2]

No of women (aged 40+) recalled to assessment, first screening round in 2016	15,626
Crude rate for women (aged 40+) recalled to assessment, first screening round in 2016	11.1%
No of women screened (aged 40+), first screening round in 2016	140,835
No of women (aged 40+), diagnosed with cancer, first screening round in 2016	1257
No of women (aged 40+) recalled to assessment, subsequent screening rounds in 2016	36,769
Crude rate for women (aged 40+) recalled to assessment, subsequent screening rounds in 2016	3.9%
No of women screened (aged 40+), subsequent screening rounds in 2016	952,331
No of women (aged 40+), diagnosed with cancer, subsequent screening round in 2016	6,570
Crude rate for women (aged 40+) recalled to assessment, all rounds in 2016	4.8%

[2] Australian Institute of Health and Welfare, *BreastScreen Australia monitoring report 2018: supplementary data tables, Table S3.1*

Table S2 outlines the cost assumptions used to estimate the costs per patient of each of the diagnostic workup sequences. The figures are presented in Australian dollars as per the original source material. We gratefully acknowledge the work of Saxby (2020)[2] who shared the cost assumptions underlying the analysis of Saxby et al (2020) [3] with us which we then adapted to our analysis. Unless a different or additional primary source is identified these figures are derived directly from their cost assumptions. While Saxby (2020)[2] also utilise Lockie et al (2018)[4] they sometimes utilise different tables in that report.

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99 **Table S2: Cost components of diagnostic workup sequences**

Activity	Cost (A$2017)	Source and other comments
1. Screening		
Invitation to screen	0.56	Saxby (2020)
ITS and other coordination	2.50	Saxby (2020)
Administration Coordination	3.17	Saxby (2020)
Mammo staff time	31.70	Lockie et al (2018) Table 18
Mammo consumables	3.50	Lockie et al (2018) Table 19
Consent	5	Lockie et al (2018) Table 18
Reading screen	15.04	Saxby (2020)
2. Assessment		
Mammo DBT staff time	30.9	Lockie et al (2018) Table 18
Mammo DBT consumables	3.50	Lockie et al (2018) Table 19
Ultrasound staff time	20	Lockie et al (2018) Table 18
Physical examination staff time	44	Assuming 10 mins of surgeon and nurse time per patient based on wage estimates in Lockie et al (2018) Table 17
Ultrasound consumables	6.50	Lockie et al (2018) Table 19
Core biopsy staff time	138	Lockie et al (2018) Table 18
CB stereo consumables	600	Lockie et al (2018) Table 19
CB stereo with clip consumables	695	Lockie et al (2018) Table 19
CB ultrasound guided consumables	86	Lockie et al (2018) Table 19
CB ultrasound guided with clip consumables	201	Lockie et al (2018) Table 19
Fine needle biopsy staff time	23	Lockie et al (2018) Table 18
Fine needle consumables	10	Lockie et al (2018) Table 19
Consent	5	Lockie et al (2018) Table 18
Open biopsy	2816	Lockie et al (2018) Table 20 – includes both consumables and labour, incurred by hospital system
Multidisciplinary team meeting	19.58	Lockie et al (2018) Table 17 Saxby (2020) cost assumptions - based on wage costs of radiologist, breast surgeon and pathologist assuming 1 to 1.25 hours are spent for every 40 cases. These costs are assumed to be incurred for every diagnostic workup involving a core biopsy and/or fine needle biopsy
Pathology	28.58	Saxby (2020). These costs are assumed to be incurred for every diagnostic workup involving a core biopsy and/or fine needle biopsy
Administration Coordination	3.17	Saxby (2020)
Delivery of results (benign)	5.83	Saxby (2020)
Delivery of results (cancer)	18.63	Saxby (2020)

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Table S3: Full list of diagnostic workup sequences of BSC service clients recalled to assessment in 2016

Diagnostic workup sequence	A. % of clients RTA after 1st screening round	B. % of clients RTA after subs. screening round
1. Screen + M	24.7%	23.9%
2. Screen + M+U	35.5%	36.8%
3. Screen + M+PE	1.1%	0.0%
4. Screen + M+CB	0.0%	1.0%
5. Screen + U+CB	0.0%	0.5%
6. Screen + M+U+PE	1.1%	0.5%
7. Screen + M+U+CB	0.0%	1.0%
8. Screen + M+PE+CB	8.6%	7.0%
9. Screen + M+U+PE+CB	19.4%	22.4%
10. Screen + M+U+PE+CB+FN	2.2%	1.0%
11. screenx2+M+U	0.0%	0.5%
12.screenx2+M+PE+CB	1.1%	0.0%
13.screenx2+2M+U+PE+2CB	0.0%	0.5%
14. Screen + 2M	0.0%	0.5%
15. Screen + 2M+U+PE+CB	0.0%	0.5%
16 Screen + 2M+U+CB+FN	1.1%	0.0%
17. Screen + 2M+2U+PE+CB	0.0%	0.5%
18. Screen + 2M+U+3CB	1.1%	0.0%
19. Screen + M+2U+PE+CB	0.0%	0.5%
20. Screen + M+2U+PE+CB+FN	0.0%	0.5%
21. Screen + M+2U+2PE+CB+FN	1.1%	0.0%
22. Screen + M+3PE+3CB	1.1%	0.0%
23. Screen + M+PE+2CB	1.1%	0.5%
24. Screen + M+U+PE+2CB	1.1%	1.5%
25. Screen + M+PE+3CB	0.0%	0.5%

M= assessment mammography, U = ultrasound, PE = physical examination, CB = core biopsy, FN = fine needle biopsy

Table S4: Recall to assessment rates, false positive rates and positive predictive value by Australian State/Territory

	Recall rate (%)	False positive rate (%)	Positive predictive value (%)
NSW	4.7	4.0	15.3
Victoria	4.7	4.0	15.2
Queensland	5.4	4.6	13.6
Western Australia	3.6	2.9	19.3
South Australia	5.6	4.9	12.8
Tasmania	3.6	3.0	16.6
ACT	4.4	3.6	17.5
NT	14.6	13.5	7.4

Given that our extrapolated national results were so heavily reliant on data from one facility in the state of Victoria, we estimated and compared the recall to assessment rates, false positive rates and positive predictive values across the different States and Territories. These results are presented in **eTable 4**. We note from this table that false positive rates were broadly similar across the most populous States, with the exception of Western Australia (while Tasmania, ACT and the NT had significant differences in these three measures from Victoria, with the NT being the most significant outlier, these are also the State and Territories with the smallest populations.)

5. References

1. *Cancer in Australia 2019. Cancer series no.119. Cat. no. CAN 123.* Canberra: Australian Institute of Health and Welfare 2019.
2. Saxby K. Unpublished cost assumptions for Saxby K, Nickson C, Mann GB, et al. The financial impact of a breast cancer detected within and outside of screening: lessons from the Australian Lifepool cohort. *Aust N Z J Public Health*. 2020;44(3):219-226.
3. Saxby K, Nickson C, Mann GB, et al. The financial impact of a breast cancer detected within and outside of screening: lessons from the Australian Lifepool cohort. *Aust N Z J Public Health.* 2020;44(3):219-226.
4. Lockie D, Clemson M, Nickson C, Petrie D, Tew M, Munro J, et al. Assessment of Return on Investment from using Tomosynthesis in BreastScreen Assessment. BreastScreen; 2018.