A Systematic Review of the Effectiveness of the Electronic Monitoring of Offenders

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Abstract

Objective: This paper reports the findings of a systematic review on the effectiveness of Electronic Monitoring (EM) on reducing recidivism. It identifies mechanisms through which EM is expected to produce reductions in recidivism rates, under what conditions, and at what cost.

Methods: Eligible studies were identified through a search strategy and quality appraised. The review uniquely combines findings of a meta-analysis alongside a realist-inspired qualitative synthesis.

Results: 34 studies met our inclusion criteria. Meta-analytic results from 18 studies found that although overall the effect of EM on recidivism was favourable, heterogeneity between studies meant that the effect was significant for studies using hazard ratios but non-significant for those using proportional data. Findings indicated statistically significant reductions in recidivism for sex offenders; when EM is compared to the alternative of prison; and in European settings. Situational and behavioural mechanisms that might plausibly reduce recidivism were identified. EM is cheaper than prison but more expensive than ordinary probation or parole.

Conclusions: The study illustrates the complexity of implementing EM. We present a theory of change for EM in the form of logic models and discuss the implications of the interaction between identified factors on implementation of EM to achieve desired outcomes.

Key words: Electronic monitoring, EMMIE, Reoffending, Recidivism, Meta-analysis, Systematic review, Logic models

INTRODUCTION

The electronic monitoring (EM) of offenders is a common but controversial criminal justice measure. It refers to a device being attached to an offender's ankle or wrist to track their whereabouts. EM is used extensively across Europe, the Americas and Australia (Geogeghan 2011, Whitehead et al. 2013, Pew Charitable Trust Report 2016) variously as a condition for bail[1]; as part of a community sentence or suspended sentence orders (curfew orders); or to allow for the early release of prisoners (home detention curfews) (Hucklesby 2008). The proposed aims of EM are many and varied, from reductions in time in custody, thereby allowing governments to reduce costs by providing cheaper alternatives to prison (Garland 2002, Hucklesby and Holdsworth 2016), to lowering recidivism through increased deterrence and through providing greater structure to offenders' lives (Hucklesby and Holdsworth 2016). Other proposed functions of EM include reducing recidivism through increased deterrence and acting as a rehabilitative tool by providing a structure to offenders' lives and the opportunity to work (Hucklesby and Holdsworth 2016).

EM technology has advanced over time. Initial systems in the 1980s were only able to determine whether a tagged offender had strayed beyond a certain distance from their home (Renzema and Mayo-Wilson 2005). The move from Radio Frequency (RF) technology to more sophisticated monitoring using Global Positioning Systems (GPS) began in the 1990s, monitoring offenders over much greater distances and at any time of the day. The proposed move towards a wider GPS-based programme in England and Wales has been described as a form of 'e governance' and represents a form of increased penalty (Nellis, 2014). EM is now widely used for various offender types as well as those on bail, terror suspects, individuals suspected of breaching immigration laws, as part of alcohol abstinence maintenance requirements and potentially, it has been suggested, EM could even be used to track those refusing to pay child support (Paterson 2007). The conditions associated with EM differ for different types of offenders. For example, sex offenders with tags may have geographic restrictions within a certain distance of schools, playgrounds and other areas in which children commonly congregate. For perpetrators of domestic abuse, by contrast, EM might serve as part of a restraining order.

EM is not without its detractors, especially when viewed more as a form of state control than a method of rehabilitation (Kornhauser and Laster, 2014). Many commentators advocate caution in the widespread use of EM systems, whether implemented alone or as part of a suite of interventions (Renzema and Mayo-Wilson 2005. A recurrent criticism concerns so-called *net-widening*, referring to the increasing use of sanctions against individuals who otherwise may not have been sanctioned (Bryne, Lurigio and Petersilia, 1992). This is often invoked in the case of low-risk offenders sentenced to EM when existing community sentences may be more appropriate (Padgett, Bales and Blomberg 2006). Likewise, the heightened surveillance of individuals released from prison and placed on EM can lead to an increase in technical violations (such as missing curfew deadlines), which, although not

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[1] We acknowledge that in some cases of EM pre-trial, the term alleged offender might be more appropriate.

crimes in the traditional sense, nevertheless often result in the incarceration of offenders who would otherwise have been in the community on parole or probation.

There is an extensive literature on the background, use and effectiveness of EM. Notable reviews include Corbett and Marx (1991), Mainprize (1996), MacKenzie (1997), Schmidt (1998), Gendreau et al. (2000) and Whitfield (2001). Taken together, these studies converge on the finding that EM is shown to have little appreciable effect on recidivism rates. In 2005, Renzema and Mayo-Wilson conducted a systematic review focusing specifically on the effectiveness of EM on moderate- to high-risk offender populations. The results were in line with prior research. Despite EM being widely advocated and implemented, Renzema and Mayo-Wilson (2005, p. 231) report that they "failed to identify any methodologically sound evaluation comparing EM to incarceration" and "failed to find any convincing evidence that EM is superior to other prison diversion programs". Only two identified studies reported promising results following the use of EM (Finn and Muirhead-Stevens 2002; Bonta et al. 2000a) but these referred to a very specific subset of offenders (sex offenders and prison divertees) and to EM implemented alongside other offender treatment programmes. Their conclusions are sobering:

> "After 20 years of EM, we have only a few clues as to its impact… If EM continues to be used as it has been used, shortsighted governments will continue to waste taxpayer dollars for ideological reasons and political gain…. Money spent on EM could be spent on empirically-tested programs that demonstrably protect our communities" (Renzema and Mayo-Wilson, 2005, p.233).

Another systematic review by Aos, Miller and Drake (2006) reports similarly a statistically non-significant effect of EM on recidivism rates. Their review of nine studies concluded that "although there is no current evidence that electronic monitoring reduces recidivism rates, it can be a cost-effective resource" when offset against jail time (2009: 284).

This paper reports the findings of a systematic review which builds on and extends the work of Renzema and Mayo-Wilson (2005). It contributes to the EM literature in the following ways. First, over a decade has passed since Renzema and Mayo-Wilson (2005). Since then, EM technology has advanced considerably, especially with the increase in GPS enabled surveillance and tracking (DeMichele and Payne, 2009) such that it might plausibly enhance the recidivism-reducing potential of EM by disrupting potential offending if tracking is conducted in real time. Second, Renzema and Mayo-Wilson (2005) included only on experimental or quasi-experimental studies involving moderate- to high-risk offenders. Here, we adopt a broader inclusion criteria including a wider range of study designs and offender populations. In doing so we depart from traditional views that contend that only the highest quality studies may be included in evidence synthesis. In the absence of a corpus of experimental evidence on EM, our view is that this inclusive approach provides a more pragmatic means of assessing the effectiveness of EM on recidivism. This is done using a transparent and systematic method, laid out in full below.

Third, previous reviews of the effectiveness of EM have focussed mainly on the *impact* of EM on various criminal justice outcome measures (such as recidivism rates). In this paper, informed by the principles of realist evaluation (Pawson and Tilley, 1997) and the recently established EMMIE framework (Johnson et al. 2015; described below), we systematically identify and synthesise information on not only the effectiveness of EM at reducing recidivism, but also on the causal mechanisms through which EM might plausibly reduce recidivism, the conditions in which EM is found to be more or less effective, the challenges associated with implementing EM and the cost effectiveness of EM programmes. This broader assessment of the research evidence is important given previous EM schemes have been marred by technological and implementation problems (National Audit Office 2006; Shute 2007, Hucklesby 2013).

The remainder of the paper is organised as follows: the next section discusses the method used to conduct the systematic review, focusing on the search strategy, inclusion criteria, data extraction, and analysis of quantitative and qualitative data. Thereafter, the results section reports on quality appraisal of studies and reports results of effect size and moderator analyses. The subsequent three sections focus on the mechanisms, implementation and economic aspects of EM. This is followed by a section which maps out the interactions between the various identified elements of the intervention in logic models. The penultimate section discusses the implications of our findings followed by the conclusion.

METHODS

Our review is guided by the EMMIE framework. Johnson et al. (2015) proposed EMMIE as a means to assess the quality and breadth of systematic review evidence in crime reduction. The first 'E' of EMMIE refers to the size and direction of the 'effect' of a given policy, programme or practice. The first 'M' refers to 'mechanism' or an explanation as to how a policy, programme or practice is expected to bring about the sought-after outcome patterns. The second 'M' refers to 'moderator' and describes the conditions that need to be in place for a policy, programme or practice to operate effectively. The 'I' refers to 'implementation' and relates to the process and challenges associated with putting a given policy, programme or practice in place. Finally, the last 'E' refers to 'Economics' which details how much an activity costs in relation to outputs, outcomes or benefits. Consistent with two recently published EMMIE-informed systematic reviews (see Sidebottom et al. 2017a, 2017b), here we use a mixed-methods approach. More specifically, we examine the effectiveness of EM at reducing recidivism using standard meta-analytic methods and explore the other elements of EMMIE using mainly qualitative methods. Different inclusion criteria and synthesis methods were used for these two components of our review, as described below.

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Search Strategy

Our search strategy involved keyword searches of 14 electronic databases[2] in January 2016, including grey literature and dissertation databases, and searches of publications by relevant government, research and professional agencies conducted by an information specialist (see Appendix A). We also performed forward and backward citation searches of all studies which met our inclusion criteria.

Inclusion Criteria

There are various types of technology which can be considered EM. For clarity, this review focuses only on the most commonly used types of EM, that is, radio frequency identification (RFID) technology to monitor the presence of an offender at a designated place (usually residence) at fixed time periods (curfews) and location tracking devices using global positioning system (GPS) technology, which constantly record the location of the offender in almost real time.

The review focuses exclusively on studies of EM that include a tagging device worn by an offender, and hence we exclude studies relating to offender monitoring via, say, CCTV or telephone, or those focusing on the tracking of goods or places. The review also does not include studies of EM used for alcohol monitoring or victim protection devices. This is because the focus of the review is on offender monitoring as a means to reduce recidivism as opposed to other aspects of surveillance.

Guided by the EMMIE framework, this review can be thought of as forming two parts with each using a different inclusion criterion. Both parts adhere to the following core criterion (a) when selecting studies for inclusion:

a) *The study must have reported an explicit goal of reducing recidivism through the use of EM.* This meant that outcome data had to refer to a measure of law-breaking (or contact with the criminal justice system regarding that law-breaking), rather than just violations of conditions associated with EM.

Beyond this, to be included in our meta-analysis to determine effect size, a study had to satisfy point a) above and:

b) *Report at least one quantitative crime outcome measure.* Outcome data could comprise official measures (e.g. reconviction or arrest data) or unofficial measures (self-reported levels of offending and/or victimization; breaches of curfew conditions).

c) *Contain original empirical research findings.*

d) *Employ a research design that permitted the computation of a reliable effect size* (i.e. an experimental or quasi-experimental evaluation design with control group or a suitable single

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[2] ASSIA (Applied Social Sciences Index and Abstracts); Criminal Justice Abstracts; Criminal Justice Periodicals; ERIC; (Education Resources Information Centre); IBSS (International Bibliography of Social Sciences); NCJRS (National Criminal Justice Reference Service); ProQuest theses and dissertations; PsycINFO; PsycEXTRA; SCOPUS; Social Policy and Practice; Sociological Abstracts; Web of Science; CINCH

study interrupted time series design). Hence, studies reporting just on treatment group were excluded.

The second part of our review, concerned with mechanism, moderators, implementation and economics, included studies that fulfilled point a) above – report an explicit goal of reducing recidivism through the use of EM – but additionally reported substantive information on *at least one* of the items below:

e) the causal mechanisms thought to be activated by EM

f) the conditions considered necessary for EM to produce its effects

g) the implementation of EM

h) the costs associated with EM

Items e to h were interpreted broadly as information that might usefully contribute to the development of EM theory, implementation and the design of EM process and impact evaluations. This information was then used to develop logic models (those that map the steps between implementation of EM and outcomes) in the interests of building a theory of how EM works given available technology and resources and under different conditions. Eligibility however was contingent on studies being primary evaluations and reporting some empirical evidence in the form of data, even if it was qualitative rather than numeric. Finally, given that EM technology has developed considerably over recent decades, we included only studies published in English during or after 2000.

Identifying Relevant Studies

All information management for this review (including screening and data extraction) was performed within the EPPI reviewer 4 software[3]. A two-stage screening process was employed. The first stage involved the screening of title and abstract by one of three review authors to exclude obviously ineligible studies (based on the aforementioned inclusion criteria). The second stage involved consulting the full texts of remaining studies to determine eligibility. Forwards and backwards citation searching were completed for all eligible studies. Tests of inter-rater reliability were carried out after the initial screening stage and secondary screening stage (with an agreement rate of 92%). Any disagreements were resolved by discussion.

Data Extraction and Management

Our data extraction instrument drew heavily on the 'Review Guidelines for Extracting Data and Quality Assessing Primary Studies for Home Office Offender reviews' (EPPI-Centre 2007), modified in accordance with the EMMIE framework based on a preliminary reading of a sample of EM studies. The data extraction instrument was largely formed when coding of the included studies began, with

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[3] See http://eppi.ioe.ac.uk/cms/Default.aspx?alias=eppi.ioe.ac.uk/cms/er4

codes added inductively to capture and/or clarify understanding about aspects of EM (for example, a code to capture active vs. passive monitoring was added during the coding process and the data extraction sheet was then 'backfilled' when this issue appeared in multiple studies)[4].

For the studies eligible for meta-analysis, two review authors independently extracted relevant information such as programme details, effect sizes, and so on. The coding instrument contained binary codes, to represent the presence or absence of information, and open question codes, so that a diverse range of information could be collected. All studies were double coded. Disagreements were resolved by discussion and, where necessary, through the involvement of a third review author.

Quantitative Data Analysis

Meta-analysis was used to estimate the effectiveness of EM overall and for relevant sub-groups. First, the data reported in the eligible studies was extracted. The effect sizes were then converted into a common metric[5]. For studies that reported the proportion of the treatment and control group that re-offended following the introduction of EM, odds ratios (ORs) and their confidence intervals were computed for each reported effect (see Anonymous 2017 for details). To assist interpretation, ORs were then converted to the *successful* outcome of 'not recidivism' using the formula 1/OR. For example, an OR of 0.8 for the unsuccessful outcome of re-offending was converted into 1/0.8 = 1.25 for the successful outcome of not-re-offending. Hence, a significant effect size of over 1 favours the treatment. The variance, and hence the width of the confidence intervals, remained the same after these conversions.

Studies that reported time to event (hazard ratio), for example time to re-arrest or re-offend, were analysed separately. A hazard ratio is an indicator of the effect of the treatment (e.g. EM) on the risk of the event of interest occurring (e.g. recidivism). The ratio can be interpreted as the change in the risk of experiencing the event of interest (i.e. recidivism) that is the result of the treatment (i.e. EM). For instance, a hazard ratio of 2 indicates that offenders in the treatment group (e.g. EM) are two times less likely to experience an event (e.g. recidivism) compared to the control group in the reference period.

Out of the five studies that reported time to event data, only one (Lapham et al. 2007) was a longitudinal study with repeated measures of the effect. As longitudinal data should not be treated as independent measures of effect, we took the mean of the time points as the effect size for this study. Effect sizes from the other four studies were used 'as is' and the models took robust variance into account. To facilitate interpretation, we coded the hazard ratios in the same direction as the odds ratios.

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[4] The full evidence appraisal and data extraction tools are available from the corresponding author.

[5] In doing this, the data is often presented in a different format than the original study and, when subjected to a different statistical test, can result in a contrary conclusion. For example, in the Tennessee Board of Parole and Probation (2007) study, the authors report percentages of the treatment and control group who had committed further offenses and their use of chi square and t-tests resulted in no statistically significant effect of EM on reoffending. When this data was converted to odds ratio it manifested as (marginally) statistically significant (see Figure 3).

Inverse variance weighting was used when combining the individual effect sizes into an overall mean effect for the reported meta-analytic models (see Anonymous 2017 for details). Q statistics were computed for each of the samples of studies used for meta-analysis to quantify the degree of heterogeneity present. Random effects models were used in all analysis, since Q could be underpowered in the small sample sizes, to discern whether the studies were homogeneous or not.

To ascertain if any methodological (e.g., research design type) or contextual conditions (e.g., EM implementation) could have influenced the overall effect size for EM, we carried out a number of sub-group analyses. For this, weighted mean effect sizes were computed for meaningful sub-groups and are presented with their associated confidence intervals.

There were two dependence structures in the data: 1) hierarchical effects, which referred to geographical areas being nested within studies, and 2) correlated effects, whereby multiple outcome data or follow-up periods were reported within studies. Sensitivity analysis was performed to determine if dependency in the data affected the results. For analyses with a sample of studies greater than ten we used robust variance estimator as an adjustment method (Hedges, Tipton and Johnson 2010). A different approach was taken for sub-group analyses with smaller sample sizes. Here the best and worst case scenario were analysed – using (respectively) the most favourable and least favourable effect sizes (from a treatment group perspective) from a single study in the analysis. Separate sensitivity analyses were conducted to assess for potential outlier bias or publication bias. For the latter, we produced a funnel plot, displaying effect sizes against their standard error and used the trim and fill method proposed by Duval and Tweedie (2000) to re-estimate the effect size of intervention accounting for potential bias.

MMIE Analysis

A team of four researchers were involved in this aspect of our review. A detailed code set was created to extract information pertaining to the mechanisms, contextual factors, implementation and economic costs associated with the use of EM to reduce recidivism. In addition to analysing the identified studies, two authors visited the EM monitoring centre for the north of England and Wales and spent the day observing the operations and interviewing practitioners about the operational aspects of the implementation of, and possible mechanisms responsible for, EM as an effective crime reduction intervention. The information obtained from these two exercises were used to create programme theories, which were then scrutinised and refined through regular group discussions. Logic models theorising how EM might work in order to achieve particular intended outcomes (often extending beyond reducing recidivism) were then constructed to elucidate the way in which elements of EMMIE conceptually interlinked to explain how EM works and under what conditions.

RESULTS

Search Results and Screening

Our search tactics returned over 4,600 records (see Figure 1). As is customary with systematic reviews, the majority of studies returned in our initial searches were found to be ineligible after the

first round of screening. A total of 373 records remained after scanning the title and abstracts and full texts for these records were retrieved. Screening of the full texts resulted in 34 records being judged eligible based on our inclusion criteria, and these were included in the final analysis and were read in detail by at least two of the authors. 18 studies (reported in 20 documents) reported a quantitative effect size and were therefore eligible for meta-analysis (see Appendix B for a summary of these studies).
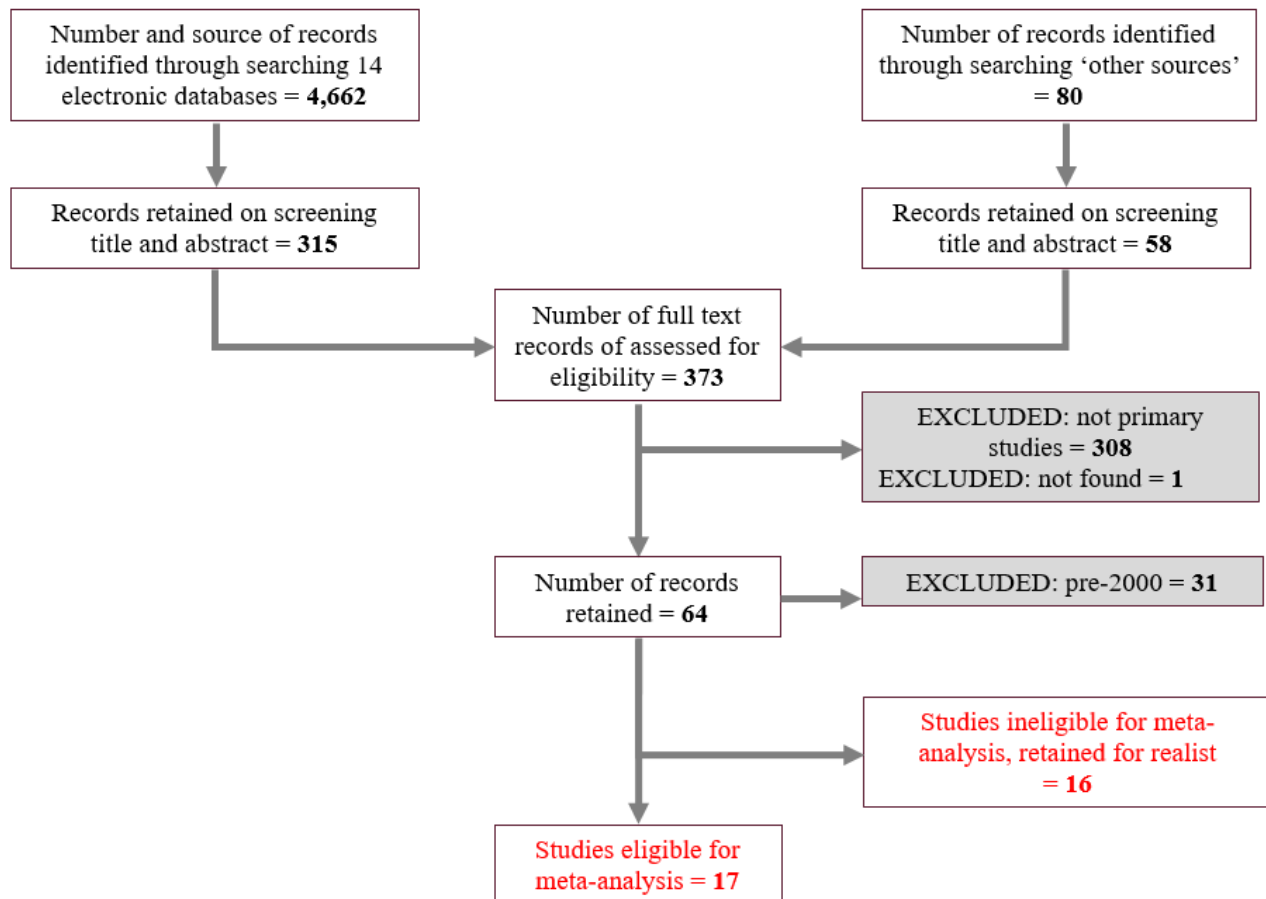
Figure 1 - Flowchart of study selection

Profile of Studies Included in the Meta-Analysis

The 18 studies included in our quantitative meta-analysis differed in their methodological approach. The majority (89%) provided various measurements of recidivism rates (e.g. rates of re-imprisonment, re-arrest or re-conviction) in the treatment and comparison groups *after* EM had been implemented. Of the 18 studies, only two (Marklund and Holmberg 2009; Pearson 2012) provided information on offending rates prior to the implementation of EM.

A minority of studies (11%, n = 2) randomly assigned individuals to treatment or control conditions[6]. The remaining studies used either a quasi-experimental design with a comparable control group or equivalent[7] (56%) or a quasi-experimental design with a non-comparable control group (33%).

Three studies (Baumer et al. 2008; Erez et al. 2012; and Sugg et al. 2001) reported data for more than one geographic area. On closer inspection, implementers in each of these areas had responsibility for delivering EM and evaluators collected data specific to each area. The prevailing assumption from this was that the areas represented independent samples within each study; that is, participants within each of the areas within a study were sufficiently separated to provide separate effect sizes. However, as noted above, this introduced some hierarchical effects into the structure of the data. In the results that follow we present these effect sizes first as if they were independent, and then conduct sensitivity analysis to validate whether the results are stable when the dependence structure is accounted for.

Evidence Appraisal of the Studies Included in the Meta-analysis

Studies eligible for the quantitative meta-analysis were independently appraised by two review authors using a four-point scale. Five domains were assessed: 1) statistical power; 2) sampling bias; 3) attrition bias; 4) data collection and 5) study design. Each domain was weighted (see Newman et al. 2012) such that the first four domain scores collectively carried the same weighting as the fifth domain (study design). The evidence appraisal score was weighted thus in recognition of the importance of the study design as a proxy for internal validity.

Each domain was scored along a numeric scale, where 4 denoted high-quality evidence, 3 medium quality, 2 low quality and 1 when information on a given domain was unclear. Any disagreements were resolved through discussion with the research team. We acknowledge that our assessment of any bias that may be present may relate more to the descriptive validity of studies rather than their internal validity (Farrington 2003).

Results of the evidence appraisal revealed that two studies (Killias et al. 2010, Lapham et al. 2007) scored high on methodological quality as measured herein (>3.5); three studies (Baumer et al 2008, Roy and Barton 2007, Tennessee Board of Corrections 2007) scored poorly (<2.00), with the remaining 13 studies distributed around the mean score of 2.65 (see Table 1).

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[6] Killias et al. (2010) and Lapham et al. (2007).
[7] The equivalent design was a regression discontinuity design, with propensity score matching, used by Marie 2009 and Marie et al. 2011.

	Statistical power and robustness	Sampling bias	Attrition bias	Data collection	Study design	Overall weight of evidence score
Bales et al., 2010	2.50	2.00	1.00	2.00	3.00	2.44
Baumer et al., 2008	2.50	2.00	1.00	1.67	2.00	1.90
Bonta et al., 2000a	2.50	3.00	2.00	3.67	2.00	2.40
Bonta et al., 2000b	2.50	2.00	2.00	3.33	3.00	2.73
Erez et al. 2012 (West)	2.00	3.00	4.00	3.67	3.00	3.08
Erez et al. 2012 (Midwest)	2.00	3.00	4.00	3.67	3.00	3.08
Erez et al. 2012 (South)	2.00	3.00	4.00	3.67	2.00	2.58
Di Tella and Schargrodsky, 2013	2.00	3.00	2.00	3.00	3.00	2.75
Finn & Muirhead-Steves, 2002	2.50	3.00	1.00	3.00	2.00	2.19
Gies et al., 2013	2.50	3.00	3.00	2.00	3.00	2.81
Killias et al., 2010	2.50	4.00	4.00	3.00	4.00	3.69
Lapham et al., 2007	3.50	4.00	4.00	4.00	4.00	3.94
Marie, 2009; Marie et al., 2011	2.50	3.00	2.00	3.67	3.00	2.90
Marklund & Holmberg, 2009	2.50	3.00	2.00	2.67	3.00	2.77
Omori & Turner, 2015	2.50	2.00	1.00	3.67	3.00	2.65
Pearson, 2012	2.00	3.00	2.00	3.00	3.00	2.75
Roy & Barton, 2007	1.50	3.00	1.00	1.67	2.00	1.90
Sugg et al., 2001	2.00	1.00	2.00	2.67	3.00	2.46
Tennessee Board of Probation and Parole, 2007	2.00	2.00	1.00	1.00	2.00	1.75
Turner et al., 2010; 2015	2.50	3.00	1.00	3.67	3.00	2.77

Table 1 – The results from the evidence appraisal assessment. Mean weight of evidence score = 2.65

Note: Scores for individual dimensions equated to judgements of 4) high quality; 3) medium quality; 2) low quality and 1) unclear from reporting. Some dimensions had multi-part answers, thus explaining fractional scores.

Meta-Analysis of the Impact of Electronic Monitoring on Recidivism

Five types of data and statistics were reported across the 18 studies[8] included in our meta-analysis. Since by definition meta-analysis pools multiple, comparable, effect sizes from more than one study, the results that follow only report on two of these outcomes: hazard ratios and proportions. These were the only two effect size measures reported in more than two studies. No correspondence between study design (e.g. RCT) and outcome type was apparent from the included studies.

Overall Effect Using Hazard Ratios

Figure 2 shows meta-analytic results of studies that report survival data (hazard ratio). This shows that the overall weighted mean effect size[9] of 1.375 is statistically significant (95% confidence interval 1.041-1.816, n=5)[10]. This indicates that, when the hazard ratio studies are considered as a whole, electronic monitoring was found to have a statistically distinguishable effect on time to recidivism in favour of the treatment.

Study name	Hazard ratio	Lower limit	Upper limit	Z-Value	p-Value	Hazard ratio and 95% CI
Bales et al	1.456	0.594	3.569	0.820	0.412	
Lapham et al	1.970	0.908	4.273	1.717	0.086	
Marklund & Holmberg	1.462	0.938	2.278	1.676	0.094	
Turner	1.282	0.468	3.510	0.483	0.629	
Finn et al	1.092	0.660	1.805	0.341	0.733	
Overall	1.375	1.041	1.816	2.244	0.025	

Favours Comparison   Favours EM
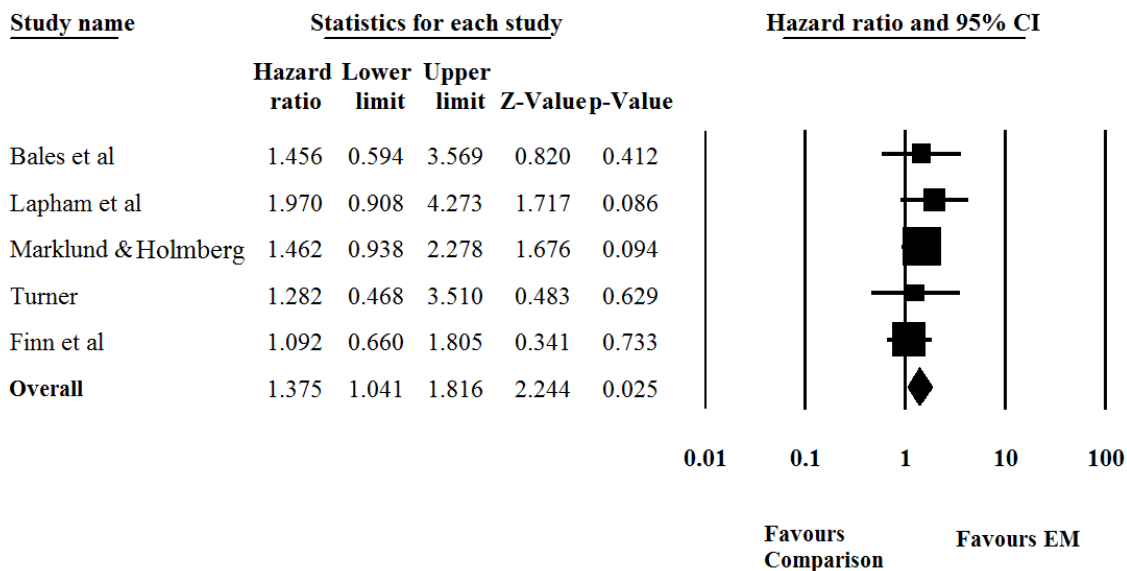
Figure 2 - Forest plot of effect sizes from studies reporting hazard ratios (95% CI)

Overall Effect Using Proportions of Recidivism

For each study that reported their results in proportions of recidivism in both the treatment and comparison groups, we first estimated the effect of intervention by computing an odds ratio and a confidence interval for each geographic area in the way described above. The outcome measure

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[8] Pearson (2012) and Erez et al (2012) (West region) both provided means and standard deviations; Finn and Muirhead-Steves (2002) provided logistic regression coefficients and Marie (2009) and Marie et al. (2011) used percentages of recidivism *but* for incomparable groups, and regression discontinuity coefficients for comparable groups.

[9] Random effects and fixed effects model results were identical here as the results converged to a fixed effects model as Q was less than the degrees of freedom.

[10] The 90% confidence interval was 1.089-1.736.

chosen from each study was the most conservative estimate of recidivism, so that (say) long-term arrest was selected over short-term arrest. General recidivism was chosen over specific offenses, since the latter were not consistently reported across studies.
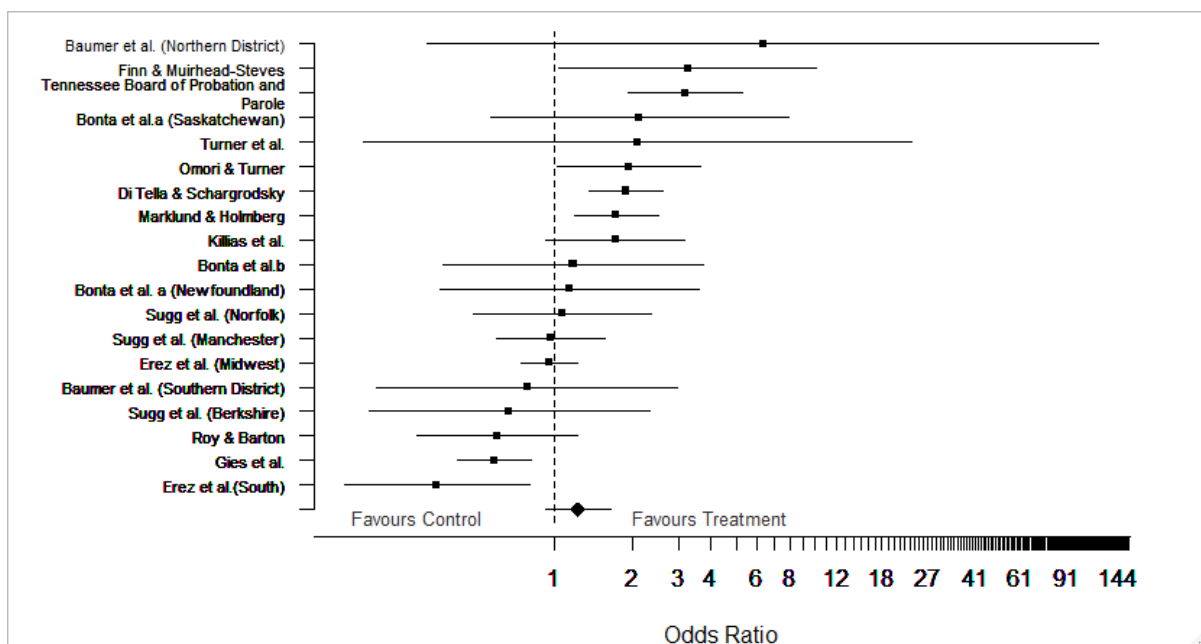
Figure 3 - Forest plot of the effect sizes from studies reporting proportions, for each geographic area, using the most stringent measure of re-offending

The overall weighted mean effect size and associated confidence intervals are shown in Figure 3. The overall result for the 14 studies reporting proportions is non-significant (ES: 1.24, CI: 0.93 – 1.64),[11] and many of the ORs from the individual studies (12 of the 20 effect size observations) are similarly non-significant[12]. Excluding the Baumer et al. (2008) (Northern District) outlier (both in terms of effect size and breadth of confidence interval) did not appreciably change our results[13]. Applying robust variance estimation to those studies that contributed multiple effects from different geographical areas produced statistically comparable results[14]. This indicates that, when the proportion effect size studies are considered as a whole, electronic monitoring is found to have no statistically distinguishable effect on recidivism rates, consistent with prior research (for e.g. Renzema and Mayo-Wilson 2005).

The fact that the results from the two types of outcome measures reported are different is noteworthy. The studies using hazard ratios were heterogeneous; the only common feature was that four of the five studies used populations from the US. They diverged on study design, targeted population (e.g., the sample included sex offenders, violent males and general offenders), type of EM used, and type of outcome data used. The studies using proportional data were similarly

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[11] 90% confidence interval was 0.97-1.57
[12] This is factual information and not used to come to any conclusion about overall effectiveness.
[13] A weighted mean effect size of 1.22 (95% CI: 0.92-1.62).
[14] Robust variance estimator generated an overall weighted mean effect of 1.25 (CI: 0.87 – 1.79).

heterogeneous, albeit the sample size for this analytic group was larger. It is evident that whilst not significant, the effect using the proportions data is in the same direction as that using the hazard ratio. Previous research has demonstrated that factors such as the quality of the study design of the primary evaluation studies can alter the significance- and sometimes the direction- of meta-analytic findings (see e.g. Boruch and Rui 2008; Welsh et al 2010). To unpack the potential role of heterogeneity in determining outcome in what follows, we perform sub-group analyses, which stratify studies on common features that are likely to vary across primary studies.

Sub-group Analyses

We next examined a large number of moderators drawn from the studies that reported proportional data, to better understand the conditions and populations for which EM has been shown to be more or less effective. These were informed through considering methodological differences but also contextual factors mentioned in the studies themselves (see ahead in Table 3). As can be seen in Table 2, non-significant effects were found when categorising studies by quality of evidence (as determined by our aforementioned evidence appraisal), the type of control group (i.e., 'business as usual'), the type of EM technology (RFID vs. GPS), and whether EM was implemented on its own or as part of a package of interventions. Geographically, only European studies exhibited a significant pooled effect, however since the sample size is three studies this result may be sensitive to additional studies being completed in this geographical region.

The results of the trim and fill procedure suggested that two studies were missing from the funnel plot of the 15 studies that provided proportional data. The original odds ratio point estimate was 1.26, with a confidence interval of 0.91-1.74. The adjusted point estimate is 1.10, with a confidence interval of 0.95-1.29. These results indicate that accounting for possible missing studies does not seem to affect the initial conclusions of the meta-analysis; that is, the adjusted mean effect size persists in demonstrating a non-significant effect of EM on re-offending. The initial and adjusted point estimates are very similar in magnitude. For this review, therefore, it appears that publication bias is not a major concern[15]. This was confirmed by a regression test for funnel plot asymmetry undertaken on the two imputed studies that demonstrated no significant differences between this and a symmetric plot (t = 0.59, df = 13, p = 0.56).

In support of this, just over a quarter of the EM studies used in the meta-analysis could be considered 'grey literature' (n = 5) since they were published outside of academic outlets. Analysis using this sub-group of studies produced a non-significant weighted mean effect (0.96, CI: 0.63-1.46). Removing the outlier from Baumer et al. (2008) (Northern District) did not make an appreciable difference to the results.

Insufficient data (i.e., comparable across multiple studies) on follow up periods, study design[16] and whether EM was monitored passively or actively prevented investigation of their potential influence on the effect of EM. Due to the small sample sizes in much of the sub-group analyses, it is likely that

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[15] Although we recognise that these technically aren't sub-group analyses.
[16] Since the two RCTs used different outcome data to one another.

some of these models are underpowered and therefore unlikely to produce significant results. However, it is notable that detectably different outcomes – some of which indicated significant effects – were found for some sub-groups. We now discuss each of these in turn.

Data subset	N studies	N Obs.	Q statistic	Mean ES	CI 95%	CI 90%	Sig?
Higher quality studies	7	7	33.47	1.21	0.84-1.74	0.89-1.64	N
Lower quality studies	7	7	16.90	1.06	0.67-1.65	0.73-1.54	N
Compared to business as usual	13	18	64.73	1.23	0.94-1.63	0.98-1.56	N
USA studies	10	11	59.55	1.17	0.81-1.70	0.86-1.61	N
Canadian studies	3	3	0.03	1.29	0.65-2.55	0.73-2.29	N
European studies	3	5	5.67	1.37	1.07-1.75	1.11-1.68	Y
GPS	8	10	54.79	1.17	0.79-1.75	0.84-1.64	N
RFID	4	6	9.21	1.42	1.05-1.93	1.10-1.84	Y
EM as standalone intervention	10	14	90.28	1.20	0.77-1.87	0.82-1.74	N
EM as a packaged intervention	8	13	33.34	0.94	0.72-1.21	0.75-1.16	N
Grey literature studies	5	9	37.89	0.96	0.63-1.46	0.67-1.37	N
Outcome as violation of EM conditions	7	9	76.30	1.04	0.60-1.79	0.66-1.64	N
Outcome as arrest	4	7	35.68	1.01	0.68-1.50	0.72-1.41	N
Outcome as reconviction	4	6	5.28	1.33	1.05-1.33	1.09-1.63	Y
Compared to prison	5	8	22.11	1.43	1.12-1.84	1.16-1.77	Y
Sex offender population	5	6	12.20	1.63	1.05-1.63	1.12-2.36	Y
High risk offender population	3	3	12.59	1.06	0.54-2.10	0.60-1.88	N
Pre-sentence	2	4	28.27	0.88	0.52-1.48	0.57-1.36	N
Post-sentence (instead of prison)	4	6	9.44	1.41	1.08-1.85	1.13-1.78	Y
Post prison	7	8	39.33	1.46	0.83-2.56	0.91-2.34	N

Table 2 – Sub-group analysis using random effect models

Study	GPS	RFID	Pre-trial	Instead of prison	After prison	24 hour	Specific period	Low/ medium risk	Sex/ violent/ high risk offender	Geographic restrictions	Stand alone	Package
Armstrong & Freeman (2011)	x				x	x			x	x		
Armstrong et al (2011)					x		x					x
Avdija & Lee (2014)									x			
Bales et al (2010)	x	x			x		x	x	x	x		x
Baumer et al (2008)	x	x			x	x			x	x	x	
Bonta et al (2000a)				x				x				x
Bonta et al (2000b)								x			x	x
Dierenfeldt (2013)					x					x		
Di Tella & Schargrodsky(2013)		x	x								x	
Erez et al. (2012)	x	x	x			x	x		x	x	x	x
Finn et al (2001)		x			x	x			x	x	x	
Finn & Muirhead Stevens (2002)					x		x		x			
Florida (2004)	x	x	x			x	x		x			x
Frost (2002)	x			x		x				x		
Gies et al. (2013)	x				x	x			x	x		x
Gowen (2000)		x	x	x	x	x				x		
Harig (2001)	x	x		x								x
Hudson & Jones (2016)	x									x	x	
Jannetta, (2006)	x				x	x			x	x		x
Killias et al (2010)		x		x			x	x		x		x
Lapham et al (2007)		x		x			x			x		x
Lobley and Smith (2000)				x			x			x		x
Marklund & Holmberg (2009)				x			x		x	x		x
Mayer et al (2003)												
Mortimer (2001)		x			x		x	x		x	x	
Nestleroad (2012)					x							
Omori & Turner (2015)	x				x	x			x		x	
Pearson (2012)	x				x				x	x		x
Roy & Barton (2007)				x							x	
Shute (2007)	x	x		x		x	x		x	x		x
Sugg et al (2001)							x				x	x
Tennessee (2007)	x				x	x			x	x	x	

Turner et al (2010)	x		x	x		x	x	x
Turner et al (2015)	x		x	x		x	x	x

Table 3 – Contextual factors mentioned in the studies

Assessing the Influence of Outcome Measurement

A range of outcome measures were reported in the 18 studies included for meta-analysis. As specified in our inclusion criteria, all of these included a measure of recidivism. Some of the studies also, and *separately,* reported violations of parole or EM conditions. We performed sub-group analysis on those categories of outcome measures that had at least three studies (see Table 2). All of these used different forms of proportional data. Whilst three studies is a small sample to include in sub-group analysis, it is not uncommon in systematic reviews (c.f. Toon and Gurusamy 2014; Schmucker, Lösel and Schmucker 2017). We acknowledge that these analyses are underpowered in the traditional statistical sense, and stress that the findings should be taken as indicative of a possible trend, rather than conclusive.
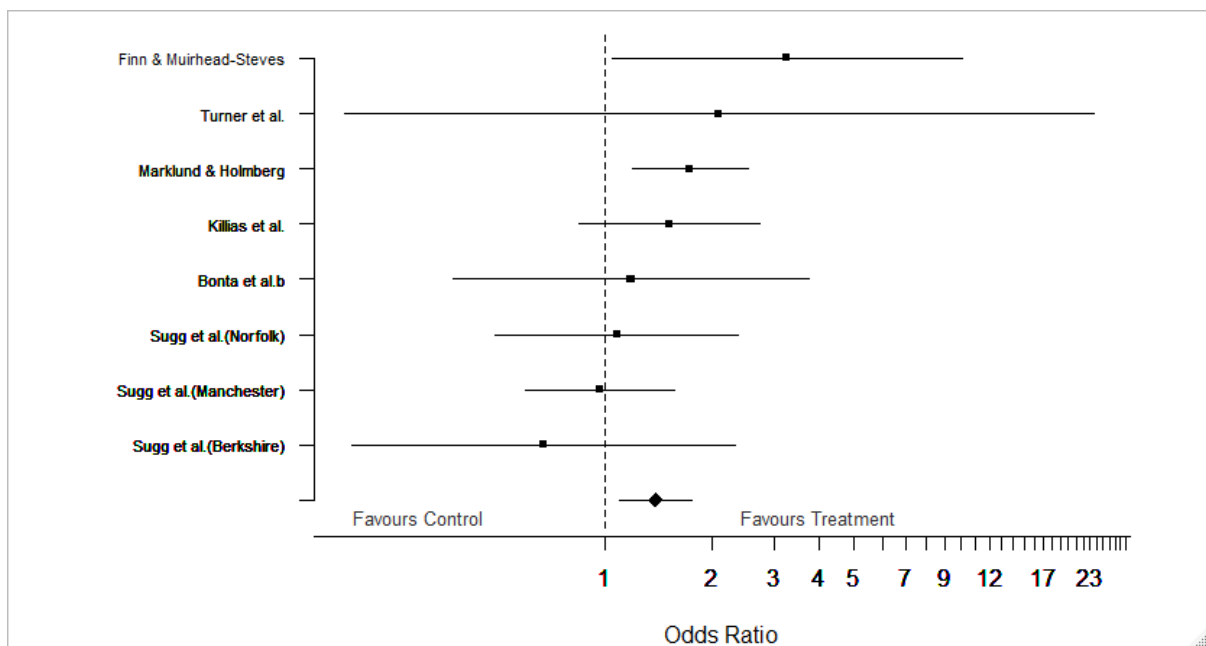
Figure 4 – Forest plot of the studies using reconviction / re-imprisonment outcome data

As Table 2 and Figure 4 illustrate, a significant weighted mean effect was observed for studies using reconviction and re-imprisonment data as the outcome measure (1.39, CI: 1.10-1.76), but the reliability of this was challenged by the sensitivity analysis using the worst- and best-case scenarios[17]. Specifically, when the worst-case scenarios were used (the least effective effect for reconvictions/re-imprisonment outcomes) the effect became non-significant. No effect was found for re-arrest outcome data or parole violations, even when sensitivity analysis was performed[18].

When EM was compared to a control group who received a prison sentence, a statistically significant effect was found for a reduction in recidivism (Table 2 and Figure 5, 1.43, CI: 1.12-1.84). This sub-group analysis did not warrant sensitivity analysis since the three studies contributing the effect sizes

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[17] For worst case scenario, ES=1.30 (CI: .0.90-1.8) for best case scenario ES=1.64 (CI: 1.24-2.16).
[18] For re-arrest data, worst-case scenario, ES=1.17 (CI: 0.79-1.71) and best-case scenario ES=1.32 (CI: 0.93-1.87). For parole violations, worst-case scenario, ES=1.16 (CI: 0.64-2.09) and best-case scenario ES=1.12 (CI: 0.64-1.97).

were independent. Whilst the number of studies in the meta-analysis would encourage caution in the reliability of this finding, it is still noteworthy.
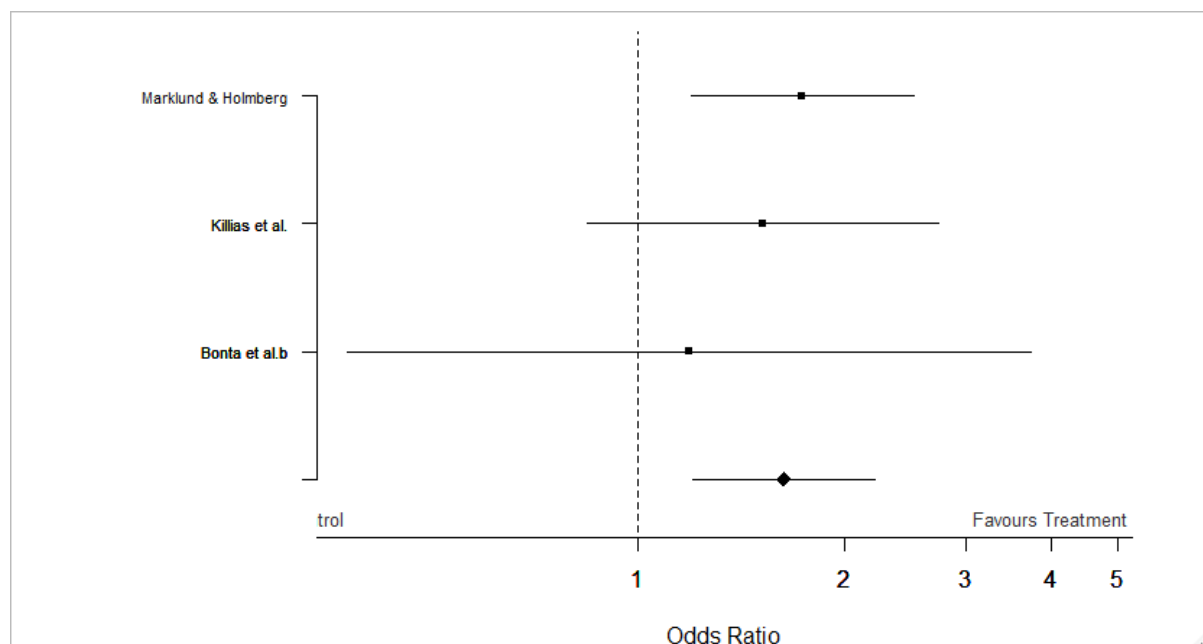

Figure 5 - Forest plot of the studies where EM implemented post-sentence (instead of prison)

Assessing the Influence of Offender Type

A statistically significant weighted mean effect *was* observed for the four studies (with five geographical areas) that examined the effect of EM on sex offenders[19] (see Table 2 and Figure 6). With a weighted mean effect of 2.41 (CI: 1.66-3.49) this was a comparatively strong crime reduction effect. This result was substantiated by the sensitivity analysis testing best- and worst-case scenarios[20].

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[19] One of which was also considered 'high risk'.
[20] For worst-case scenarios for sex offender sub-group analysis ES=1.68 (CI: 1.12-2.52) and for the best-case scenario ES=2.41 (CI: 1.67-3.49).
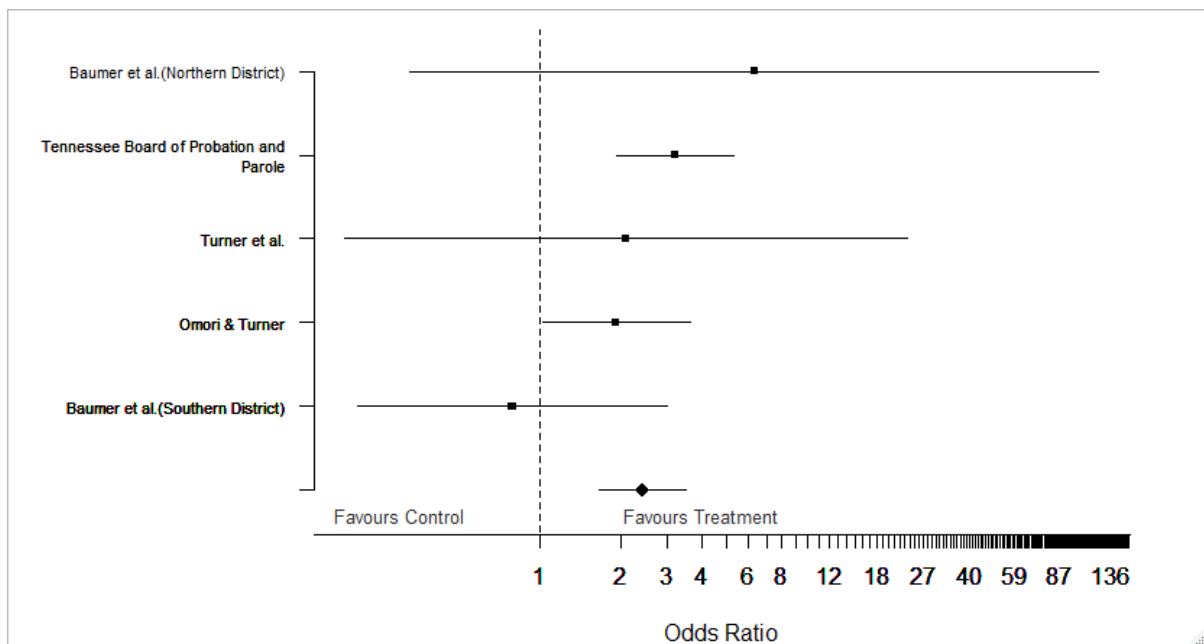
Figure 6 - Forest plot of the studies focusing on sex offenders

However, the impact of assessed risk levels of offenders (high risk vs medium or low risk) on reoffending was found to be statistically insignificant (Anon 2017)

Assessing the Influence of Timing in the Criminal Justice System

Finally, the timing for when EM was implemented within the criminal justice process appeared to make a difference. The use of EM post-sentence (instead of prison[21]) was seen to have a statistically significant effect on reducing recidivism, although as we caution above, these results are tentative due to the very small sample sizes. In addition, pre-sentence use of EM – that is, before the offender's case was adjudicated at court – was seen in two studies, across three geographical areas. Here, the result in Table 2 shows a non-significant effect, but it is worth noting that the two effect sizes taken from Erez et al. (2012) were both in a backfire direction. Erez and colleagues studied the use of pre-sentence EM in domestic abuse cases, and the results for these indicate that EM used in these conditions appears to *increase* recidivism when compared to controls.

The next three sections describe the mechanisms, implementation and economic aspects of EM programmes. This information was synthesised through largely qualitative techniques using the broader range of studies included in the review.

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[21] On the surface this seems to be identical to the sub-group reported above with control groups that were in prison. However, two of the post-sentence group (instead of prison) group did not have control groups that were in prison. Only one study (Marklund and Holmberg 2009) was included in both sub-group analyses.

MECHANISMS: HOW IS EM ASSUMED TO WORK?

A number of potential mechanisms through which EM may plausibly reduce recidivism, either directly or indirectly, were elucidated in the thirty-three studies judged eligible for the review. Mechanisms mentioned in these studies can be split broadly into situational mechanisms and behavioural or social mechanisms. Two studies did not mention any mechanisms, 10 studies mentioned only situational mechanisms, three studies mentioned only behavioural mechanisms and the remaining 18 studies referred to both behavioural and social mechanisms in varying levels of detail (see Table 4). It should be noted that some of these are inferred from the description of the programme and its implementation, rather than being specifically identified by the primary study authors as programme mechanisms.

Situational Mechanisms

EM is a form of situational crime prevention (SCP) (Clarke, 1997). Situational mechanisms[22] refer to the ways in which manipulation of the immediate environment can bring about reductions in crime in the here-and-now, specifically through increasing the risk, increasing the effort, reducing the rewards, removing excuses and reducing provocations. The most common situational mechanism mentioned in the studies reviewed here (23 studies) was that EM *increased the (perceived) risk* of offenders being caught if they broke, or attempted to break, the law or the conditions of their monitoring programme. Offender surveys suggest that the feeling of being watched when under EM increases their risks of being caught than if they were not (Bales et al 2010).

Formal surveillance, a technique for increasing the risk of detection, is strengthened under EM since the offenders' location can be monitored either partially when they are under curfew at home, for example, or round the clock if they are on active GPS monitoring, reducing the potential for anonymity as their whereabouts can be ascertained at all times (Frost 2002; Turner et al. 2015). Rather than replacing supervision, EM is designed to enhance supervision, providing information to relevant authorities in cases where the offender is believed to have breached the terms of their monitoring or committed a crime, and effectively extending the network of guardianship over an offender.

As well as increasing the risk of being caught, 12 studies suggested that EM *increased the effort* required to commit offences and avoid detection. Although EM devices by themselves do not prevent reoffending, the effort required to remove the device so as to be undetected indirectly affects reoffending behaviour. This relates to the considerable effort required to circumvent or deactivate contemporary EM devices, which are generally robust and unaffected by water (Florida 2004; Gies et al. 2013). EM systems are designed to alert the provider if the ankle bracelet or the receiver is tampered with (Gies et al. 2013; Lobley and Smith 2000; Tennessee 2007) and excuses or explanations are not looked upon favourably, so this is a risky strategy for the offender. Similarly, the

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[22] Mentioned in italics

implementation of exclusion zones for offenders, especially child sex offenders or domestic violence perpetrators, increases the effort required to find suitable targets (Omori and Turner 2015, Erez et al. 2012).

Another way in which EM is assumed to reduce recidivism is by *removing the excuses* which offenders use to justify their behaviour. To assist compliance, EM programmes have an explicit set of rules that must be followed (Erez et al. 2012; Harig 2001; Mortimer 2001). Flexibility in terms of adapting curfews to suit employment patterns have been found to aid compliance (Bales 2010; Erez et al. 2012; Mayer et al 2003) both by ensuring that the offender can be gainfully employed and does not have time or need to commit crimes, and also to ensure they are able to avoid technical breaches. Other programmes (Erez et al. 2012; Harig 2001; Lapham et al. 2007; Turner et al. 2010) insist on abstinence from drugs and alcohol and enforce this through regular and/or random testing, further removing excuses which offenders may try to use for non-compliant or undesirable behaviour (such as committing property offences to support addiction or breaking curfew to obtain drugs or alcohol). Thus, the compulsory attendance of drugs or alcohol abstinence programmes as well as requirement to be gainfully employed act in the twin capacity of removing excuses for offending behaviour (excuses such as poverty, unemployment or addiction) and also work in combination with behavioural and social mechanisms discussed below.

Reducing provocations is the final situational mechanism which may be activated by EM to reduce recidivism. By enforcing curfews and exclusion zones, EM may assist in neutralising peer pressure by removing the influence of criminogenic settings and/or peers (Mortimer 2001; Killias et al. 2010). Viewed this way, however, it is also plausible that EM may lead to an *increase* in frustration and stress, by confining tagged individuals to their home for long hours and enforcing increased contact with family (Bales et al. 2010; Lobley and Smith 2000; Pearson 2012). This could lead to *increasing* rather than *reducing* provocations, which could ultimately lead to a backfire effect and see an increase in crime or undesirable behaviour, although no study explicitly reported this outcome.

Behavioural and Social Mechanisms

While situational mechanisms help explain what factors in the immediate environment permit the criminal to commit a crime, social mechanisms explain how broader social conditions and settings affect different individuals' morality and exposure to different social and moral contexts (Wikstrom 2007). If the causes of crime are considered to be grounded in either habitual or deliberative processes (Wikstrom 2007), then the solutions are to be found in influencing those habits or rationalising processes that allow individuals to commit crimes. Thus, behavioural and social mechanisms attempt to influence offender habits and thinking patterns that permit them to commit crimes.

While the use of curfews leading to extra time at home may increase stress in some individuals, others have been shown to benefit from more contact with family members in pro-social settings (see Table 4 below). Developing better relationships with family members was thus mentioned as having a positive effect on offenders' lives and behaviours, including reducing recidivism (Erez et al.

2012; Finn and Muirhead-Stevens 2002; Killias et al. 2010). EM is also argued to provide more stability and structure in offenders' lives, through enforcing curfews and deadlines, and through the need to gain and maintain employment, which is often part of the requirements of the programme (Finn and Muirhead-Stevens 2002; Hudson and Jones 2016; Lapham et al. 2007; Mortimer 2001). This too is seen as a means through which criminal behaviour can be reduced.

EM programmes also often involve a mandatory therapeutic component, with offenders required to attend therapy as part of their EM conditions (Pearson 2012). This can help offenders overcome criminogenic needs that hitherto have been associated with their offending (such as drug and alcohol abuse) as well as encourage and reinforce pro-social behaviours. For example, by removing some of the triggers for offending, including substance abuse and anti-social behaviours, it is hoped that recidivism will be reduced. Finally, offenders on EM are protected from the negative effects of incarceration, either completely, if they are placed on EM rather than being imprisoned, or partially, if EM allows for early release from incarceration (Bonta et al. 2000b; di Tella and Schargrodsky 2013; Finn and Muirhead-Stevens 2002; Hudson and Jones 2016; Omori and Turner 2015). Avoiding the influence of criminogenic people and prison conditions might be helpful for reducing recidivism rates for these offenders (Finn and Muirhead-Stevens 2002).

IMPLEMENTATION: WHAT NEEDS TO BE IN PLACE FOR EM TO WORK?

This section identifies the implementation challenges associated with operating an EM scheme. Only three studies[23] did not contain any information regarding implementation. We refer here to four main challenges identified across the studies we reviewed: technological issues, staffing issues, programme design, and information and consent issues. A summary of the issues reported by studies can be found in Table 5.

Technological Issues

The availability and quality of EM technology and accompanying equipment directly affects performance. Factors such as equipment malfunction, loss of signal or power, battery failure, lack of communication between various databases, and inadequate broadband capacity were identified as being impediments to successful implementation across the studies. For example, the use of RFID technology requires the presence of a power line, and often a telephone (Gowen 2000; Florida 2004; Killias 2010; Erez et al. 2012). Having telephone contact is vitally important for a variety of reasons. Not just for monitoring presence through RFID technology, but also to maintain contact between the parole/monitoring agent and the offender in case of alerts due to unauthorised absences and/or for clearing false alerts (Gies et al 2013; Baumer et al 2008; Tennessee 2007; Mortimer 2001; personal communication with EM monitoring staff). Further, telephone contact was required as part of the supervision protocol (Pearson 2012), for parole agents to monitor progress of offenders (Turner et al 2010) and even to reinforce themes visited during supervision sessions and provide support to offenders (Erez et al. 2012).

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[23] Bonta 2000a, Marklund and Holmberg 2009 and Sugg et al 2001

Study	Increasing risk	Increasing effort	Removing excuses	Reducing provocations	Family contact	Employment	Therapy	No drugs/ alcohol	No prison
Armstrong & Freeman (2011)		x	x						
Avdija & Lee (2014)	x								
Bales et al. (2010)	x	x			x	x	x		x
Baumer et al. (2008)	x		x						
Bonta et al. (2000a)	x						x		x
Bonta et al. (2000b)	x				x		x		x
Dierenfeldt (2013)	x	x							
Di Tella & Schargrodsky (2013)							x		x
Erez et al. (2012)	x	x			x		x	x	
Finn & Muirhead-Stevens (2002)	x				x	x	x		x
Finn et al. (2001)	x		x						
Florida (2004)	x								
Frost (2002)	x								
Gies et al. (2013)	x	x	x					x	
Gowen (2000)	x								
Harig (2001)		x	x					x	
Hudson & Jones 2016	x				x	x			x
Jannetta, (2006)	x		x				x		
Killias et al. (2010)				x	x				
Lapham et al. (2007)	x		x			x	x	x	
Marklund & Holmberg (2009)	x					x	x	x	
Mortimer (2001)			x	x	x				
Nestleroad (2012)	x								
Omori & Turner (2015)	x	x							x
Pearson (2012)	x	x	x	x	x		x		
Roy & Barton (2007)									
Shute (2007)	x	x							
Sugg et al (2001)									
Tennessee (2007)	x	x						x	
Turner et al (2010)	x	x						x	
Turner et al. (2015)	x	x						x	
Total	23	12	9	3	7	5	9	8	6

Table 4 - Mechanisms through which EM produces effects by studies

Study	Technology/ equipment	Training	Resources/ workload	Coordination	Programme objectives	Programme administration	Adequate Information	Impact on family/ social life	Response to breach
Armstrong & Freeman (2011)	x	x				x	x		
Armstrong et al (2011)				x				x	x
Avdija & Lee (2014)									
Bales (2010)	x	x	x			x		x	x
Baumer et al (2008)		x	x		x	x			
Bonta (2000a)									
Bonta (2000b)									x
Dierenfeldt (2013)								x	
Di Tella and Schargrodsky (2013)	x		x			x		x	
Erez (2012)	x		x	x	x			x	x
Finn et al (2001)	x			x		x	x	x	x
Finn Muirhead-Stevens (2002)	x						x		x
Florida (2004)	x								x
Frost (2002)	x		x	x					x
Gies et al. (2013)	x	x	x			x			x
Gowen (2000)	x		x			x			x
Harig (2001)	x	x	x			x	x		x
Hudson & Jones (2016)	x			x				x	
Jannetta, (2006)	x		x						x
Killias et al (2010)	x					x		x	
Lapham et al (2007)	x							x	x
Lobley and Smith (2000)				x			x		x
Marklund & Holmberg (2009)									
Mayer et al (2003)	x							x	x
Mortimer (2001)	x						x	x	x
Nestleroad (2012)									x
Omori & Turner (2015)			x						
Pearson (2012)	x		x	x	x			x	x
Roy & Barton (2007)				x					
Shute (2007)	x	x	x						x
Sugg et al (2001)									

Tennessee (2007)	x	x	x	x	x	x
Turner et al (2010)	x	x	x	x		x
Turner et al (2015)						x

Table 5 – Implementation factors mentioned in the studies

Smooth functioning of GPS can be affected by loss of EM signals in certain locations or places and can cause serious problems for offenders, especially if this happened at their place of residence or work (for e.g. Bales et al. 2010; Baumer et al. 2008). Jannetta (2006) reports that lack of adequate wireless capability on laptops meant agents cannot track offender movements while out in the field. Problems with equipment and loss of signal, errors in signal, overload of false positives or technical alerts were said to cause agent complacency and failure to act when a real violation occurred (Gies et al. 2013). Overall, while some of these technological shortcomings are surmountable, others were more difficult to overcome.

Staffing Issues

Staff involved in running an EM programme included personnel from prisons, probation, the police, monitoring companies and criminal justice agencies. They were identified as being pivotal in the implementation and success of EM. Problems often arise when too much control is exercised by social workers (Mayer et al 2003); correction officers are unhelpful (Bonta et al. 2000b); or personnel are inflexible or lack discretion in the enforcement of programme rules (Erez et al. 2012; Pearson 2012). Unless staff are completely on board, understanding the requirements of the programme as well as its aims and objectives, and are willing to co-ordinate effort, it is unlikely that the programme will succeed (Bales et al. 2010).

Specialized training requirements identified for EM staff included training for installing, maintaining and monitoring EM equipment, responding to alerts (genuine or false) and supervising offenders. Continuous or active (as opposed to passive monitoring which is done at a fixed point in time after a lag) GPS monitoring implies agents have to be on call 24/7 leading to burnouts and rapid turnover of staff (Tennessee 2007). Staff replacement in such cases of burnout and rapid turnover were reported to be a problem. Inadequate staffing and staff training are also mentioned as being impediments to the success of EM programmes by a number of studies.

Further, monitoring staff or social workers/probation agents responsible for responding to violations reportedly felt unsafe while conducting home visits – especially at night (Tennessee 2007). Thus, a co-ordinated approach between probation staff, monitoring agents and police is required in order to ensure smooth operation of EM.

Programme Administration

Proper care and attention at the planning and design stage was identified as being essential for the success of any EM programme, with objectives, guidelines and expectations developed in advance of implementation (Baumer et al. 2008). Studies highlighted the importance of explicit identification of programme goals and objectives, clarity of roles and responsibilities, and provision of clear lines of communication and governance between various agencies involved in the EM programme.

Identification of programme goals and objectives ought to guide the process of choosing suitable offenders for EM programmes. For example, programmes which include low risk offenders for extended periods have lower chances of being successful operations (Bales et al. 2010; Erez et al.

2012; Pearson 2012) especially if the intended outcome is to reduce recidivism in the longer term. The assignment of suitable offenders cannot be left to individual whims as identified in one study where offenders were sentenced to prison or put on EM depending on whether judges were conservative or progressive (Di Tella and Schargrodsky 2013).

Information, Communication and Consent Issues

A number of information-related issues are important for successful implementation of EM programmes. Mortimer (2001) indicates that early-release prisoners need to have information about the scheme and that staff ensure better screening and preparation of potential curfewees, as well as clarification of support available after release. Armstrong et al. (2011) note that both the offender and their family need adequate support to deal with the stress of release, and Armstrong and Freeman (2011) say that offenders need orientation training to live with EM. Moreover, good communication between case worker and offender is also deemed crucial for successful implementation (Erez et al. 2012).

The issue of consent refers to the offender consenting to being on EM, as well as in some cases having the ability to pay for EM (Erez et al. 2012; Bales et al. 2010; Finn and Muirhead-Steves 2002). The use of RFID monitoring requires the offender to have a residence with a landline installed for the express purpose of monitoring the offender's presence during curfew (Finn and Muirhead-Steves 2002; Killias et al. 2010). In some instances, this involves getting agreement from family members that they would leave the landline free for the purpose of the monitoring unit having an open line of communication with the offender (Tennessee 2007). However, problems were reported when families felt socially stigmatized, were inconvenienced, and suffered embarrassment when a family member was on EM and were, therefore, less co-operative than anticipated (Bales et al. 2010, Erez et al. 2012, Pearson 2012). However, increasingly the use of landlines has been replaced with mobile technology, except in areas with no satellite signal.

In summation, successful implementation of EM requires good communication between the various agencies responsible for implementation, as well as clear programme design, administrative responsibilities and communication strategies laid out from the outset.

ECONOMICS: HOW MUCH DOES EM COST?

The final component of our review concerned economics. Twenty-two studies provided information about the costs of EM, either for offenders or pre-trial accused persons. Most of these studies compared the cost of implementing EM against the cost of imprisonment, albeit without taking into account the costs associated with recidivism while on EM (something that cannot happen if the offender is in prison). Only one study calculated the financial impact of crimes committed while offenders were on EM – calculations which included lost quality of life for the victims as well as the direct costs of the crimes themselves (Frost 2002).

It is evident that variation in the costs of EM is largely dependent upon the type of monitoring technology employed – programmes using RFID technology are generally cheaper than GPS

programmes. The latter also vary depending on whether passive or active monitoring is used. The 24-hour nature of GPS monitoring requires staff members to be available throughout the monitoring period.

While GPS is patently more expensive than RFID monitoring, prior research[24] shows that both forms of EM are considerably cheaper than a prison sentence alternative, up to two and a half times cheaper (Di Tella and Schargrodsky 2013). Bales et al (2010) estimate that for the cost of one inmate in prison for a year, six could be on GPS and 28 could be on RFID, showing potentially significant cost savings to the state or county running the EM programme. However, the cost of EM is consistently estimated as higher than traditional parole or community supervision (Amori and Turner 2015, Gies 2013). Furthermore, studies suggest that the cost of active supervision on GPS is three times the cost of traditional parole (without EM) (Turner 2015). Therefore, while EM may be cost saving compared to imprisonment, authorities may need to consider the financial implications of putting offenders on EM rather than traditional supervision or parole – the decision to adopt EM should depend on whether such supervision is essential as it is not only more expensive but may have a net widening effect by increasing the number of individuals being controlled by the criminal justice system. Moreover, active offender tracking requires more resources, including more staffing, making it more expensive than passive systems. In turn, passive tracking on GPS is more expensive than RFID systems. Other factors to consider include the installation and maintenance costs of equipment.

As discussed previously, staff are an important moderator of the effectiveness of EM, and these are one of the largest costs associated with any EM programme. Staff are required to initially decide whether an offender is suitable for an EM programme, requiring a full risk assessment. Probation or parole officers are sometimes required to monitor offenders, whereas other times it is private agencies who carry out this role. Where monitoring centres are set up, these incur staffing costs which are often 24-hours in nature. Additional costs include training costs at various stages of the programme, and for staff equipment including mobile phones, laptops, wireless internet facilities and phone lines (for details of costs calculated by the studies see Anonymous 2017).

According to the literature consulted here, the total EM programme costs often run into the millions of pounds or dollars (Mortimer 2001; Lapham et al. 2007). Studies indicated that start-up costs can vary depending on the type of equipment which must be purchased or rented from a private contractor who runs the programme. Some of these costs are offset by programmes which require the offender to contribute towards the costs of monitoring, although this seems to be exclusively in the US (none of the European programmes mentioned this component).

MAPPING INTERACTIONS

In addition to summarising the main findings of the EM literature, this review highlighted the complexity in reliably estimating the effectiveness of EM, in part because of the observed variation in what EM programmes are expected to achieve and how the sought-after outcomes are expected

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[24] Amori and Turner 2015, Armstrong et al. 2011, Bales 2010, Marklund and Holmberg 2009, Harrig 2001, Mortimer 2001, Gowen 2002, Lobley and Smith 2000

to come about. For those planning and managing an EM programme, it is therefore important to map out the pathway from intervention to intended outcomes thereby helping to "identify the human and financial resources needed to operate a program, the program activities targeted by these resources, and the intended products of program activities" (Anderson et al. 2011: 34).

We use this as motivation for furthering our understanding of how EM should work using logic models, focusing on the recognition that EM has several different aims and is introduced under a variety of conditions and contexts. According to Bickman (1987) "a logic model is a plausible and sensible model of how a programme will work under certain environmental conditions in order to solve identified problems" (cited in McLaughlin and Jordan 2004: 8). The model is constructed using a "series of hypotheses... sort of ...if resources then programme activities, if programme activities then outcomes for targeted customer groups" (McLaughlin and Jordan 2004: 24). The EMMIE approach facilitates the development of a theory of change (Sidebottom and Tilley 2018) with the aim of making review evidence more transparent and cogent for policy makers as well as to draw attention to the complex aspects of an intervention that might be otherwise ignored (Anderson et al. 2011).

In an effort to conceptually combine the Context-Mechanism-Outcome Configurations (Tilley 2013), two high level models are now detailed. Thus, we include moderator, implementation and economic factors as those setting out the Context, mechanisms as the identified Mechanisms in order to achieve the intended effect or Outcome. These indicate the complexity of determining the effectiveness of EM given the plethora of starting points, available resources and combinations of conditions that might trigger different mechanisms for the intervention to achieve intended outcomes. Figure 7 shows just one particular configuration of a pathway for EM of an offender (in this case a sex offender) under given contextual factors (outlined in blue) and implementation issues (outlined in green) that might affect the activation of particular mechanisms (outlined in yellow) to achieve certain intended outcomes (grey boxes outlined in red). In the specific situation shown in Figure 7, the only mechanism activated is increasing the risk, but modifying the moderator conditions (adding probation conditions) or the implementation issues (not enough buy-in from family) might activate different mechanisms and pathways to ultimately achieve the intended outcomes (or not). Indeed, Figure 8 shows a different configuration that has different starting points and activates other causal pathways to achieve the intended outcomes. Thus, when the evidence indicates that EM had a significant positive result on sex offenders it could be (for example) because, more often than not, EM was combined with a therapeutic component. The interactive models shows that in the absence of sufficient mapped evidence, it is difficult to reliably attribute the positive impact to EM itself. It might be that being on EM compelled attendance at these mandated therapeutic activities, and it was these that actually led to the reduction in recidivism behaviour.
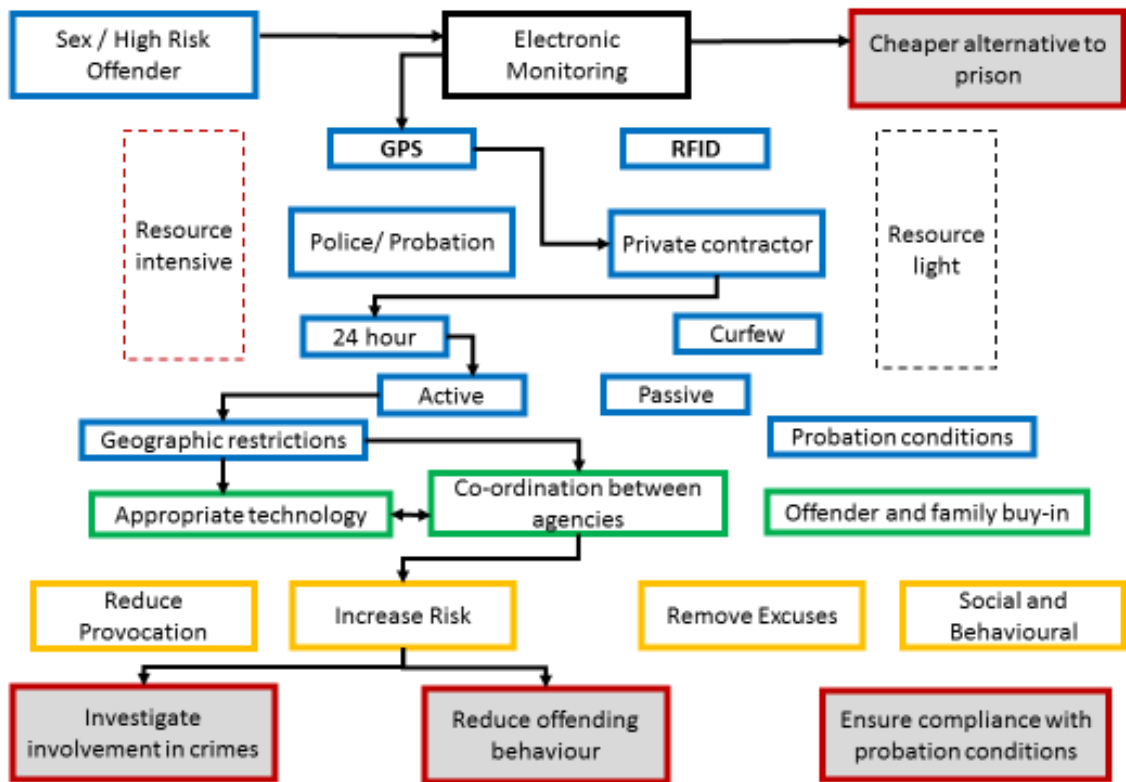
Figure 7 – Logic model for a sex offender on 24-hour active monitoring using GPS technology operating within inclusive geographic zones only
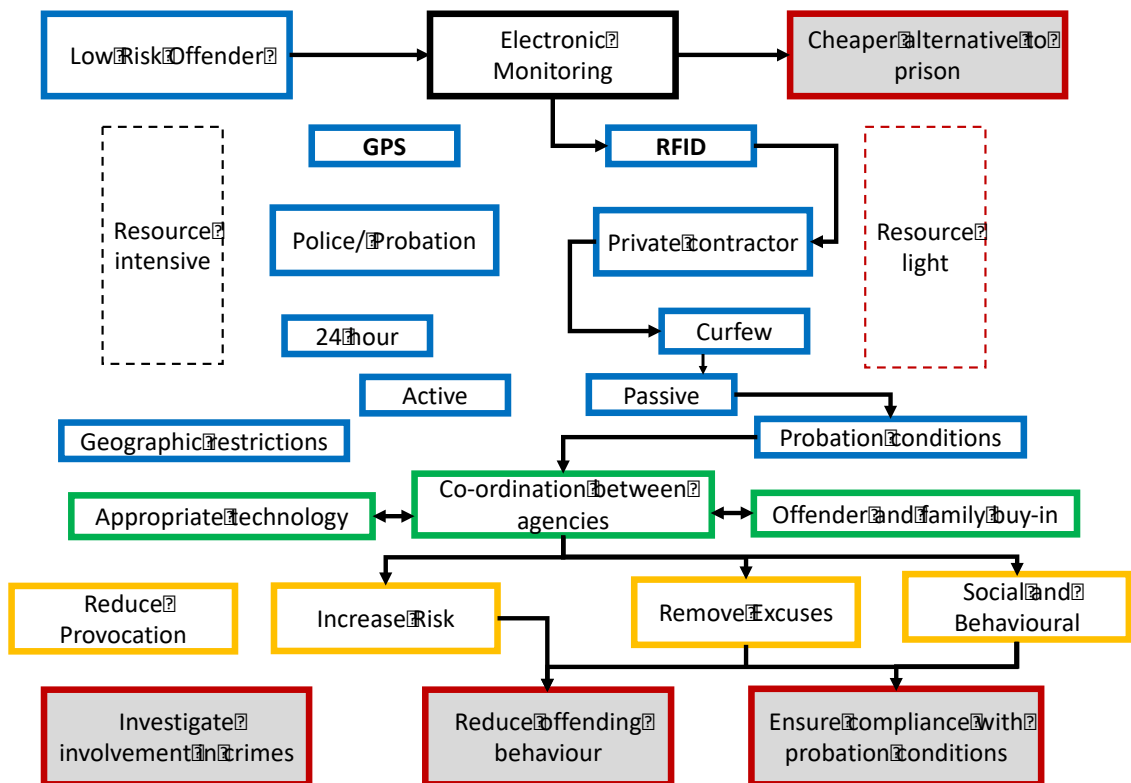
Figure 8 - Logic model for a low risk offender on a 12-hour curfew passive monitoring using RFID technology and having to comply with probation conditions of employment

To increase the reliability of conclusions, a full evaluation would map out a process or logic model for each particular programme, identify the potential pathways and specific causal mechanism/s that might plausibly be activated (for similar discussions see Eck and Madenson 2009; Weisburd et al. 2015), identify and measure interim outcomes associated with particular mechanisms (through surveys or observation) and use the data to ascertain how and whether the intervention is successful (and if not, why not) as well as whether unintended outcomes are produced (Eck 2017).

DISCUSSION

EM is widely advocated and implemented across Europe, North America and Australia. It is touted as a programme that can cut costs, reduce prison overcrowding and reduce recidivism. Despite the popularity of EM, previous primary studies and reviews of the effectiveness of EM have produced sobering findings. This is clearly observed in the systematic reviews of Aos et al (2006) and Renzema and Mayo-Wilson (2005), who concluded that EM has been applied seemingly without adequate thought, producing little effect on recidivism rates and at times giving rise to unintended consequences.

This paper has updated and extended the systematic review of Renzema and Mayo-Wilson (2005) by taking a more inclusive approach to the evidence reviewed, in terms of the methodological rigor of studies included. In addition, informed by EMMIE, it considered not just the effectiveness of EM at reducing recidivism but also the conditions in which EM is more or less effective, the mechanisms through which EM might plausibly lead to reductions in recidivism, the challenges associated with implementing and sustaining a EM programme, and the financial costs and benefits of doing so. In doing so we have revealed new insights into the causal pathways through which EM might plausibly work to reduce recidivism.

Overall, our findings indicate that EM has been shown to produce positive effects for certain offenders (such as sex offenders), at certain points in the criminal justice process (post-trial instead of prison), and perhaps in combination with other conditions attached (such as geographic restrictions) and therapeutic components. The evidence suggests it is less effective at reducing recidivism for other offender sub-groups and under different conditions. These contrasting results may explain why the overall effect of EM on recidivism found herein for proportional data was non-significant, since the range of studies synthesised were notably heterogeneous. That said, the overall effect of EM on recidivism found herein for studies that reported hazard ratios *was* statistically significant in the direction of a crime reduction effect. It would appear that more studies are required to clarify this equivocal finding in future meta-analyses. Although overall the meta-analysis did not indicate a statistically significant result, most individual studies showed an effect in the desired direction and the finding that the available evidence was not sufficient to show a significant effect, is not the same as saying that the evidence showed there was no effect.

There is limited evidence in the studies reviewed here to enable confident identification of the *mechanisms* that produced the effect of EM on recidivism, something that is often lacking in crime prevention evaluations (Velonis, Mahabir, Maddox and O'Campo 2018). Although increasing the risk

was posited as the dominant mechanism through which EM was expected to work, surveys and offender feedback in the studies reviewed indicated that social and behavioural mechanisms were also thought to be a powerful influence in encouraging prosocial behaviour. While increased exposure to prosocial situations is proposed as being beneficial to reducing likelihood of future offending, in some cases it caused a great deal of stress for offenders and family members as a result of forced interaction during curfews of up to 12 hours (Armstrong et al. 2011; Pearson 2012; Erez et al. 2012).

The context in which EM was implemented had a considerable impact on which of the above mechanisms (if any) would be activated thereby increasing the chances of a favourable result. The evidence highlighted four issues that could prove to be major obstacles to successful implementation of EM. Foremost among these were inadequate staffing and technological problems. Although EM technology is becoming ever more sophisticated, inadequate coverage of satellite technology and equipment failures cannot be ruled out (Bales et al. 2010; Baumer et al. 2008, Gies et al. 2013). Further, smoother co-ordination between staff of various agencies and appropriate training for them were recommended for improving the effectiveness of the intervention (Bales et al. 2010). Moreover, the need for careful planning and a clear vision regarding aims, objectives and implementation at the programme administration level was identified as essential (Baumer et al. 2008). Finally, effective communication, both for obtaining consent from offenders and family members and building rapport between agencies and participants was considered central to the success of EM interventions (c.f. Mortimer 2001; Armstrong 2011; Erez et al. 2012). What the evidence analysed here failed to highlight was another condition that has a substantial impact on how EM works, namely, the swiftness and certainty of response to a breach[25]. Since the efficacy of response is largely dependent on the agency or agencies responsible for overseeing and managing compliance and responding to breaches, shared understanding of roles and responsibilities and effective communication become key.

The economic argument for EM, in most of the studies, was focused on comparing it against imprisonment and other offender management techniques. Findings indicated that although EM was cheaper than prison, it was more expensive than parole (c.f. Bales et al. 2010; Amori and Turner 2015; Gies 2013), and some types of EM (continuous monitoring with GPS) were more expensive than others (static monitoring with RFID).

Our results paint a complex picture. Firstly, the intended outcomes of EM programmes are not always reducing recidivism, but can be reducing prison overcrowding, or simply be seen as a more cost-effective offender management method. Our logic models suggest that *moderators* (conditions under which EM operates) can impact *mechanisms* (how it operates) in achieving the *effect* (intended outcomes) differently depending on *implementation* issues involved. The situation is further complicated by the fact that EMMIE aspects of EM are interrelated in complex and non-linear ways. Sometimes the intended outcomes or *effect* (for example, compliance with probation requirements) and *implementation* issues (namely, resource availability) will dictate the *moderator* conditions (such

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[25] Private communication with practitioners at the EM monitoring centre in England and Wales.

as choice of type of technology and application of geographic restrictions). At other times the existence of particular contextual *moderating* factors (c.f. type of offender or legal requirement to be in employment or attend drug and alcohol programmes) will necessitate the triggering of specific (social or behavioural) *mechanisms* to achieve the desired *effect* (rehabilitation) and might be dependent on certain *implementation* requirements being fulfilled (such as attendance monitoring).

CONCLUSION

Many countries use EM in an effort to both reduce recidivism and as a proposed cost-effective alternative to prison. The increased dependence on GPS technology to monitor high risk offenders involves a huge investment in resources and equipment and the evidentiary value of EM data is still unestablished across many jurisdictions. Using EM to increase the risk of getting caught and convicted requires necessary legal provisions and the appropriate training of staff and members of the criminal justice system. Thus, it is important for policymakers to be very clear about the main effect that EM programmes are intending to achieve – reducing reoffending, avoiding prison overcrowding, and/or finding a cheaper alternative to prison. Further, it is also important for policymakers to understand the wider context within which the EM programme is to be implemented, *what is legally permissible* (this includes laws permitting tagging, which offender types can be put on EM, at what stage in the criminal justice system, what additional conditions can be imposed alongside etc.)*; what is administratively possible* (this includes who will be responsible for installation, maintenance, monitoring and responding to breaches and overseeing partnership work involved)*; and what is operationally practical* (in terms of what resources are available, whether the technology can be supported, and whether the response is swift and sharp enough).

Future research should focus on understanding and measuring the impact of stand-alone EM programmes compared to EM programmes that combine other treatments and interventions. To improve our understanding of how and when EM is most effective, future evaluation studies might also usefully look to collect data on the various elements of the programme as well as contextual factors to measure the impact of the component factors and identify effective causal mechanisms that achieve the intended outcomes[26]. This was largely absent from the primary studies identified here.

Finally, it is important to note that EM programmes can be inequitable, especially those that require that the offender contribute to the cost, have a permanent residence, and the necessary support structure (in the form of agreement from family members to EM). Expansion of EM as an offender management technique should ensure fair and equitable treatment in the interests of avoiding litigation and upholding basic principles of procedural justice for all.

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[26] Our coding instrument will be made available on request. Further, key programme features of interest for future evaluations are included in our contextual and implementation tables (Tables 3, 4 and 5)

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Appendix A – Electronic databases searched

ASSIA (Applied Social Sciences Index and Abstracts)

Criminal Justice Abstracts

Criminal Justice Periodicals

ERIC (Education Resources Information Centre)

IBSS (International Bibliography of Social Sciences)

NCJRS (National Criminal Justice Reference Service)

ProQuest theses and dissertations

PsycINFO

PsycEXTRA

SCOPUS

Social Policy and Practice

Sociological Abstracts

Web of Science

CINCH

Appendix B - An example of the search syntax used in electronic databases

"electronic monitor*" OR tag* OR curfew* OR "random calling" OR "verifier anklet" OR "verifier wristlet" OR "verifier bracelet" OR ((house OR home) W/1 (arrest OR detention OR confinement OR incarceration)) AND "crim* OR illegal* OR illicit* OR delinqu* OR offend* OR parole* OR probate* OR incarcerate* OR recidivism* OR convict* OR felon* OR misdemeano* OR bail*"

Appendix C – List of sources searched for grey literature

In collaboration with an information specialist, we searched the publications of the following government, research and professional agencies:

- Australian Institute of Criminology

- Canadian Police College

- Centre for Problem-Oriented Policing (Tilley Award and Goldstein Award winners)

- Danish National Police (Politi)

- European Crime Prevention Network

- Finnish Police (Polsi)

- Institute for Law and Justice

- New Zealand Police

- Norwegian Ministry of Justice

- Police Executive Research Forum

- Police Foundation

- Rand Corporation (public safety publications)

- Swedish National Council for Crime Prevention

- Swedish Police Service

- The Campbell Collaboration reviews and protocols

- The Netherlands Police (Politie)

- UK College of Policing (Polka)

- UK Home Office

- UK Ministry of Justice

- Urban Institute

- US National Institute of Justice

- Vera Institute for Justice (policing publications)

The following resources were also searched:

- Google

- Google Scholar

- Academic Search Premier (EBSC)

- ProQuest Sociology

- Rutgers Criminal Justice Grey Literature Database

- OSCE Polis Digital Library

Appendix B – Summary table of studies included in the meta-analysis

Study	Study setting	Method	Sample size	Data period	Data	Outcomes	Offender type	Comparison group
Bales et al., 2010	Florida, USA	Quasi-experimental 1 (comparable groups)	Treatment group = 87, Comparison group = 47 (across both areas)	Shorter than EM period	Cox's regression and hazard ratios	absconding from supervision, revocations for technical violations, and revocations for misdemeanour or felony arrests	Medium- and high-risk offenders	Non-EM probation conditions
Baumer et al., 2008	Indiana, USA	Quasi-experimental 2 (non-comparable groups)		Unclear	Proportions	Arrests, non-compliance with EM conditions, 'not successful'	Sex offenders	Non-EM probation conditions
Bonta et al. 2000a	BC, SK, NL, Canada	Quasi-experimental 2 (non-comparable groups)	Treatment group = 262, Comparison group = 256 (across all areas in prison) and 30 (non-EM probation)	Longer than EM period	Proportions	Re-offending	Non-specific	1) in prison and 2) non-EM probation conditions
Bonta et al. 2000b	NF, Canada	Quasi-experimental 1 (comparable groups)	Treatment group = 54, Comparison group = 100 (released from prison) and 17 (non-EM probation)	Longer than EM period	Proportions	Reconvictions (police data)	Non-specific	1) released from prison and 2) non-EM probation conditions

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Study	Study setting	Method	Sample size	Data period	Data	Outcomes	Offender type	Comparison group
Di Tella & Schargrodsky (2013)	Buenos Aires, Argentina	Quasi-experimental 1 (comparable groups)	Treatment (RFID EM) group = 386, Non-EM comparison group = 1,140.	Various – in most cases longer than EM period.	Raw data and regression analysis	Arrests	Offenders awaiting trial	Formally in prison awaiting trial
Erez et al. 2012	USA ('West', 'Midwest' and 'South' regions)	Quasi-experimental 1 (comparable groups)	Treatment (GPS EM) group = 1,087, RF EM comparison group = 632, Non-GPS comparison group = 437, in prison comparison group = 1,223, Non-EM probation = 725 (across all areas)	Longer than EM period	Proportions	Arrests and non-compliance with EM conditions	Domestic violence offenders	1) RF EM group, 2) Non-GPS EM group, 3) in prison, 4) non-EM probation conditions
Finn & Muirhead-Steves (2002)	Georgia, USA	Quasi-experimental 2 (non-comparable groups)	Treatment group = 128, comparison group = 158	Longer than EM period	Raw data, logistic regression and hazard ratios	Reimprisonment	Violent male offenders (inc. sex offenders and homicide)	Non-EM probation conditions
Gies et al. (2013)	California, USA	Quasi-experimental 1 (comparable groups)	Treatment group = 392, comparison group = 392	Unclear	Proportions	Arrests, non-compliance with EM conditions, return to custody	High risk gang offenders	Non-EM probation conditions

Study	Study setting	Method	Sample size	Data period	Data	Outcomes	Offender type	Comparison group
Killias et al. (2010)	Switzerland	Randomised control trial	Treatment group = 115, comparison group = 117	Unclear	Proportions	Reconvictions, self-reported offending	Non-specific	Community service
Lapham et al. (2007)	Oregon, USA	Randomised control trial	Standard DISP = 118, standard DISP no EM = 118, standard DISP no vehicle sale = 116, standard DISP no EM no vehicle sale = 120	Longer than EM period	Hazard ratios	Re-arrest	Drink drivers (repeat offenders)	Four treatment groups: with and without EM, with and without mandatory vehicle sale
Marie (2009); Marie et al. (2011)	UK	Quasi-experimental 1 (regression discontinuity with comparable groups)	Treatment group = 63,584, comparison group = 126,906	Longer than EM period	Regresion estimates	Conviction (Courts data)	Non-specific	Released from prison
Marklund & Holmberg (2009)	Sweden	Quasi-experimental 1 (comparable groups)	Treatment group = 260, comparison group = 260	Unclear	Proportions, hazard ratios	Reconvictions		Non-EM probation conditions
Omori & Turner (2015)	California, USA	Quasi-experimental 1 (comparable groups)	Treatment group = 94, comparison group = 91	Longer than EM period	Proportions	New offence, non-compliance with EM/probation conditions	High risk sex offenders	Non-EM probation conditions
Pearson (2012)	Winnipeg, Canada	Quasi-experimental 1 (comparable groups)	Treatment group = 45, comparison group = 42	Longer than EM period	Mean and sd of offences	Charges for vehicle theft, other crime and for non-compliance	Young vehicle-theft offenders	Non-EM probation conditions

Study	Study setting	Method	Sample size	Data period	Data	Outcomes	Offender type	Comparison group
Roy and Barton (2007	Indiana, USA	Quasi-experimental 2 (non-comparable groups)	Treatment group = 118, comparison group = 51	Unclear	Proportions	New offence, non-compliance with EM/probation conditions	Drink drivers	Day release centre
Sugg et al. (2001)	Berkshire, Manchester and Norfolk, UK	Quasi-experimental 1 (comparable groups)	Treatment group = 261, comparison group = 51 (across all areas)	Longer than EM period	Proportions	Reconvictions	Non-specific	Combination and community servce orders
Tennessee Board of Probation and Parole (2007)	Tennessee, USA	Quasi-experimental 2 (non-comparable groups)	Treatment group = 493, comparison group = 370	Unclear	Raw data	New charge, non-compliance with EM conditions	Sex offenders	Non-EM probation conditions
Turner et al. (2010; 2015)	California, USA	Quasi-experimental 1 (comparable groups)	Treatment group = 94, comparison group = 91	Longer than EM period	Proportions	New offence, non-compliance with EM/probation conditions	Sex offenders	Non-EM probation conditions