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The benefits and complexities of integrating mixed method findings using the Pillar Integration Process: A workplace health intervention case study

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1 **Title:** The benefits and complexities of integrating mixed method findings using the Pillar
2 Integration Process: a workplace health intervention case study

3

4

Abstract

5 The Pillar Integration Process was developed to facilitate integration of mixed method data,
6 but there is limited historical application of this approach in complex intervention evaluation.
7 To test the applicability of the technique, this paper presents two case studies examining the
8 efficacy of a workplace intervention. The research included a pilot RCT and process
9 evaluation. The case studies illustrate the benefits of applying the Pillar Integration Process to
10 elicit a comprehensive understanding of intervention efficacy and to design better
11 interventions. This paper contributes to the mixed methods research by advancing the
12 technique through considering inherent philosophical assumptions, and evidencing the value
13 of integrating methods within, as well as across, ‘qualitative’ and ‘quantitative’ categories.

14 *Keywords:* physical activity, complex intervention, process evaluation, complementarity

15

16

Background

17 In the social sciences, there is a long history of mixed method research (MMR)
18 occurring in fieldwork, particularly when conducting in-depth case studies, which typically
19 combine interview, observation and survey methods (Pearce, 2012). The historical argument
20 for combining different methods within one study is triangulation; to offset bias of different
21 methods and strengthen the validity of research via corroboration of findings (Johnson et al.,
22 2007; Tritter, 2007). However, different methods are unlikely to be tapping into the same
23 aspect of a phenomenon in MMR, as quantitative approaches seek generalizability whereas
24 qualitative approaches value rich, detailed insights (Mukumbang, 2023). Thus, it is unlikely
25 that results will always conform (Blaike, 1991; Hesse-Biber, 2012). A different rationale for
26 using MMR is ‘complementarity’; seeking enhancement and interpretability of research
27 (Greene et al., 1989). A study of health researchers’ use of MMR found that complementarity
28 was the most widely cited purpose for combining methods (O’Cathain, Murphy, & Nicholl,
29 2007). The complementarity approach assumes that different methods produce different types
30 of knowledge that can be combined to advance knowledge (Simons, 2007) and that
31 divergence of findings can uncover new questions and lead to a more sophisticated
32 understanding (Hesse-Biber, 2012).

33 **MMR and Critical Realism**

34 The conceptualization of mixed methods is inextricably tied to philosophical
35 underpinnings (Denzin, 2010) and many researchers urge against an unreflexive,
36 aparaadigmatic approach to conducting MMR which overlooks the influence of both (implicit)
37 researcher assumptions, and the ineliminable assumptions attached to methods (Lipscomb,
38 2008; Ryba et al., 2020). Whilst some researchers adopt a ‘dialectic’ approach whereby
39 quantitative components of MMR are underpinned by post-positivism and qualitative

40 components are underpinned by constructivism, this approach draws criticism around
41 mutually exclusive ontological and epistemological positions inevitably leading to the
42 incompatibility of their corresponding research methods (Liu, 2022). The single-paradigmatic
43 stance considers a unified philosophic position underpinning the research process to be
44 critical in MMR. There are paradigms that mixed methods researcher have argued to be
45 compatible with MMR including grounded theory (Lui, 2022), phenomenology (Martiny et
46 al., 2021; Mahoy & Onwuegbuzie, 2013), and critical realism (Ryba et al., 2020).

47 Critical realism moves beyond the positivist-interpretivist dichotomy to provide a
48 more nuanced account of the nature of reality (Bhaskar, 2014). Critical realism asserts that
49 there is an objective reality, however it rejects the notion that we have unmediated access to it
50 as knowledge is positioned as value-laden and as such we can only understand ‘reality’ from
51 within a particular discourse (Mukumbang, 2023; Ryba et al., 2020). One of the hallmarks of
52 critical realism is its approach to causation; rather than advocating a regularity view of
53 causation, realists support an open-system view of causation (Sayer, 2000). Such a view
54 infers that the outcome of an intervention is dependent on how the intervention interacts with
55 the presence of other behavioral influences (Clark, 2013); there is no universality to the
56 outcome of an intervention, as its power to elicit change is context dependent (Zachariadis et
57 al., 2013), and thus realism primarily focuses on uncovering causal mechanisms rather than
58 outcomes (Bonell et al., 2022; Shearn et al., 2017). Realist evaluators argue that, in order for
59 evaluations to be useful, it is imperative to seek to understand what works, for who, how, and
60 in what context, which means theorizing and testing psychosocial mechanisms that trigger
61 intervention outcomes in different implementation contexts (Dalkin et al., 2015).

62 Both qualitative and quantitative methods are compatible with the ontological and
63 epistemological assumptions of critical realism. Rather than having a ‘go to’ methodological

64 approach, critical realists select methods to answer particular research questions based on the
65 “capability and complementarity of different methods to convey different kinds of knowledge
66 about generative mechanisms” (Zachariadis et al., 2013). A retroductive approach to research
67 is advocated by critical realists whereby there is an explicit focus on generating and testing
68 explanations (Mukumbang, 2023; Næss & Jensen, 2002). Combining methods enhances
69 explanation of mechanisms and contextual factors instrumental in shaping intervention
70 outcomes, re- conceptualized as extensive (quantitative) and intensive (qualitative)
71 procedures (Ryba et al., 2020). Quantitative methods are appropriate for measuring simpler
72 and more stable elements of a system and can demonstrate causal mechanisms by controlling
73 for other possible mechanisms, whereas qualitative methods can be used to explore
74 complexity and instability and for understanding mechanisms in particular contexts, to build
75 explanatory accounts (Bonell et al., 2022; Mukumbang, 2023).

76 **Integration within Mixed Methods: the Pillar Integration Process**

77 Integration refers to interaction between the different data sources in MMR
78 throughout the research process (Plano Clark, 2019; Fetters & Molina-Azorin, 2018). Fetters,
79 Curry & Cresswell (2013) described different ‘fits’ of integration including confirmation
80 (reinforcing insights), expansion (divergent or expansive insights) and discordance
81 (inconsistent or contradictory insights). Integration of findings at the stages of analysis and
82 interpretation is central to MMR as synthesis can produce *enhanced* knowledge (Bazeley,
83 2016), which has potential to contribute to transformative change (Lynam et al., 2019).
84 However, in practice, it is uncommon for ‘mixing’ to occur beyond the data collection phase
85 (Bazeley & Kemp, 2012; Fetters and Freshwater, 2015), due to both epistemological and
86 practical changes of integration, including misaligned timelines of different components, and

87 journal word count limits motivating researchers to publish different components separately
88 (Guetterman et al., 2020; Uprichard et al., 2016).

89 Approaches and solutions to integrating data have been developed and described
90 within the MMR field. When designing MMR it is helpful to align data sources to the same
91 construct(s) and to identify ‘points of interface’ (Plano Clark, 2019; Haynes-Brown &
92 Fetters, 2021). Integration at the analytic stage can be broadly categorized as to whether it
93 involves ‘integration through narrative’ (i.e. presenting findings thematically following
94 independent analysis), or ‘joint displays’ (i.e. more comprehensive integration of data
95 through visual means, such as using a matrix) (Fetters et al., 2013; Guetterman et al., 2015).
96 It is generally felt that the more significant and nuanced integration that joint displays permit,
97 compared to the integration through narrative approach, is likely to enhance the value of
98 MMR though eliciting a deeper understanding of where findings produce different types of
99 knowledge, and where there is convergence and divergence of findings (Bazeley 2012;
100 O’Cathain, Murphy & Nicholl, 2010). The joint display technique can be adopted when
101 different data sources exist for the same ‘case’, which can be an individual, setting, or
102 topic/theme (Younas et al., 2021).

103 Johnson et al., (2019) developed a joint display technique called the “Pillar
104 Integration Process” (PIP), citing a current dearth of “specific, transparent, well-defined
105 analytical techniques to support the integrated joint display method” as a rationale for
106 developing PIP. The approach includes four sequential stages following initial analyses:
107 listing, matching, checking, and pillar-building, and the approach provides a tool for
108 researchers to present the process and findings of mixed methods integration (Johnson et al.,
109 2019).

110 **Complex Intervention Evaluation and PIP**

111 There is increasing recognition within the complex intervention literature that
112 adopting mixed methods is advantageous for developing a nuanced understanding of whether
113 an intervention works and why, how and in what context (Borglin, 2015; Farquhar et al.,
114 2011) and to facilitate an understanding of the interactive and emergent effects of
115 interventions (Clark & Clark, 2016). The Medical Research Council framework (Skivington
116 et al., 2021), implies the requirement to utilize mixed methods, in that it recommends
117 evaluating both process and outcomes, and there is an increasing recognition that
118 interventions and the context within which they are implemented cannot be easily or usefully
119 separated (Paparini et al., 2020). Taking such an approach facilitates refinement and an
120 understanding of the transferability of interventions (Bonell et al., 2022). A recent review
121 (Mackenzie et al., 2018) indicates that mixed methods are increasingly being adopted to
122 evaluate interventions within the workplace health field (e.g. Brakenridge et al., 2018;
123 Grunseit et al., 2013; Mackenzie et al., 2021; van Berkel et al., 2013).

124 Since the relatively recent development and publication of the PIP approach (Johnson
125 et al., 2019), studies that have adopted the PIP approach are starting to appear within the
126 literature, albeit outside of the workplace health and intervention evaluation fields (Ang &
127 Opiniano, 2020; Creaser et al., 2022; Flanagan et al., 2020; König & Dreßler (2021); Parey,
128 2020; Richards et al., 2022; Ryan et al., 2022; Stangle & Fringer, 2021) and all but two of the
129 papers provided no description of the philosophical stance underpinning their application of
130 PIP; Parey (2020) took a dialectical approach and Stangle & Fringer (2021) cited Dewey's
131 pragmatism, however neither specifically reflected on these in the context of their application
132 of PIP. Methodological discussion of PIP, whilst absent in the majority of papers, included
133 that merging of methods enhanced: understanding of mechanisms in context (König &

134 Dreßler (2021), opportunities for methodologically and visually synthesizing the data
135 (Richards et al., 2022) and triangulation of data and validity of analysis (Ryan et al., 2022).

136 This paper presents empirical work in the form of two PIP case studies from a
137 workplace intervention evaluation, which aimed to increase physical activity and reduce
138 sedentary behavior amongst office-based employees. PIP was identified and applied
139 following the collection and initial analysis of data and thus did not inform the design of the
140 study. The methodological aim of this paper is to examine the applicability of PIP to a
141 complex intervention evaluation. We do this through description of the context and
142 development of the PIP case studies, followed by presentation of the PIP case studies, and
143 finally, reflection on the benefits, challenges and complexities of mixed method analyses
144 using PIP, including exploring epistemological issues inherent to mixed method analyses.

145 **Method**

146 **Background to the Study**

147 The PIP case studies presented herein were developed post-hoc from data collected as
148 part of a workplace sit-stand desk intervention evaluation using MMR. The work was
149 underpinned by a critical realist perspective, given the compatibility of MMR with critical
150 realism, and its ontological position on causality which is applicable to examining the
151 mechanisms underpinning complex interventions (Mukumbang, 2023; Ryba et al., 2022). The
152 intervention is considered to be complex due to consisting of multiple components, and
153 through being delivered across different organizational settings where complexity arose
154 between the intervention and its context (Skivington et al., 2021). The intervention was
155 delivered in two non-profit office-based workplaces and there were two ‘versions’ of the
156 intervention. The first version was a multi-component intervention which was based on the
157 socio-ecological model and included organizational (emails from senior management),

158 environmental (sit-stand desk) and individual (motivational interview-style phone calls)
159 strategies to encourage increased standing and physical activity. The second version of the
160 intervention included a sit-stand desk only; see Hall et al., (2019a) for a detailed description
161 of the interventions. The evaluation aimed to address two distinct research questions (RQs):
162 RQ1. What is the efficacy, and the mechanisms of actions, of a multi-component sit-stand
163 desk intervention designed to reduce sitting, and increase standing and physical activity?
164 RQ2. What are the processes that influence the feasibility and acceptability of sit-stand desk
165 implementation and use?

166 **Pilot RCT**

167 A pilot RCT (n = 30) was conducted to understand whether the intervention was
168 efficacious (RQ1), including three arms: (1) the multi-component intervention, (2) the sit-
169 stand desk only intervention, and (3) usual desk-based working practice (no sit-stand desk)
170 control. Participants self-reported behaviour type and context, and device-based measures
171 (ActivPAL3 and Actigraph GT3X+) assessed sitting, standing and physical activity, for
172 seven days at baseline, 2-weeks, 3-months, 6-months, and 12-months.
173 For device-based data to be included within the analysis, the minimum criteria of nine hours
174 wear per day, four hours wear during work hours (9am - 5pm) on weekdays, two valid days,
175 and one valid week day, had to be met. GT3X+ data was processed using ActiLife 6.10.3 and
176 the raw data was summarized into 15 second epoch activity counts. Activity intensity was
177 calculated according to the cut-points developed by Troiano et al., (2008). ActivPAL data
178 was processed in STATA. An algorithm was run to distinguish between monitor wear and
179 non-wear/sleep (Bodicoat et al., 2016). Using an adapted data scoring code (Bodicoat et al.,
180 2016) multiple variables were produced, including time spent in sitting/lying bouts lasting 0-
181 30 mins and 30+ mins, and total number of sit-stand transitions. ANOVA was conducted to

182 examine changes in the ActivPAL and GT3X+ variables and Spearman's rho correlation
183 analyses were conducted to assess whether any demographic or organizational independent
184 variables were significant predictors of outcome variables. The intervention reduced
185 workplace sitting, on average, by 38 minutes, however there was no significant effect on
186 workplace physical activity, or any of the outcome measures across the whole day. The only
187 variable found to be a predictor of outcomes was income; lower income was associated with
188 a reduction in sitting during work hours. Full details of data collection, analysis and results
189 are available elsewhere (Hall et al., 2017).

190 **Process Evaluation**

191 A process evaluation, underpinned by the then-current MRC Guidelines for
192 evaluating complex interventions (Craig et al., 2008), was conducted to examine the
193 mechanisms underpinning the efficacy of the intervention within the implementation context
194 (RQ1) and the feasibility, and acceptability of sit-stand desk implementation and use (RQ2)
195 from the perspective of sit-stand desk users and organizational stakeholders. The updated
196 MRC guidelines recognize the complexity and non-linearity of interventions and emphasize
197 the importance of context and mechanisms in developing and evaluating interventions and
198 generating programme theory (Skivington et al., 2021). To gain an understanding of how
199 contextual factors interacted with the intervention to influence the delivery, acceptability and
200 efficacy of the intervention (Moore et al., 2015), in-depth qualitative methods including semi-
201 structured interviews and ethnographic observations were employed.

202 Three formal phases of observation, each consisting of approximately 10 working
203 days, were conducted within each of the participating workplaces, and 185366 words of field
204 notes were recorded. Semi-structured interviews were undertaken with 15 participants, of
205 which five received the multi-component intervention, seven the sit-stand desk only

206 intervention, and three were in the control group. Twenty-six interviews were conducted with
207 wider stakeholder employees, whose work roles and responsibilities were implicated in sit-
208 stand desk provision. Interviews averaged 41 minutes in length. Utilizing NVivo 10.0,
209 reflexive thematic analysis was undertaken to collectively analyze the interview and
210 observational data (Braun & Clarke, 2019). Full details of data collection, analysis and
211 results are available elsewhere (Hall et al., 2017). Papers reporting on sit-stand desk
212 implementation (stakeholder perspectives) and use (sit-stand desk user perspectives) have
213 subsequently been published (Hall et al., 2019a, 2019b).

214 **Sit-Stand Desk Intervention Evaluation: Mixed Method Design and Integration**

215 *Mixed Method Study Design*

216 Qualitative and quantitative methods were employed to answer distinct but
217 interrelated parts of the research questions, thus mixed methods were primarily utilized for
218 complementarity (Zachariadis et al., 2013). The conduct of the pilot RCT and process
219 evaluation was convergent (Leech and Onwuegbuzie, 2009) as they occurred simultaneously
220 over an extended period. Data collection time-points were strategically planned to allow
221 preliminary findings to inform subsequent data collection, meaning there was an element of
222 interdependence between study components. Figure 1.0 illustrates the mixed method study
223 design. Data from the pilot RCT and process evaluation were initially analyzed and reported
224 separately; we identified the PIP approach to data integration after the evaluation design had
225 been determined. The data from the pilot RCT and the process evaluation that related to RQ1
226 (understanding efficacy) were subsequently interwoven, using the PIP approach, to enhance
227 knowledge generation (Fetters and Freshwater, 2015).

228 [Insert figure 1 here]

229 ***Mixed Method Interpretation: Pillar Integration Process***

230 PIP - a joint display method involving four sequential stages of listing, matching,
231 checking, and pillar building - was developed to integrate data (Johnson et al., 2019). We
232 adopted PIP in two different ways to facilitate the integration of findings pertaining to
233 intervention efficacy, originating from the pilot RCT and the process evaluation. PIP
234 approach A, in line with the examples provided in Johnson et al., (2019), involved the
235 integration of data across ‘thematic’ cases from across the entire data set. PIP approach B
236 involved the integration of data for a single ‘participant’ case. The particular case was
237 selected due to the wholeness of the data set which included a fully completed diary and
238 GT3X+ and ActivPAL data for each time point, and relevant observation and interview data.
239 Additionally, we knew that the qualitative data was ‘rich’ and would permit meaningful
240 integration with the quantitative data. The case example provided in PIP approach B is not
241 intended to be representative, but rather it enables detailed examination of the influence of
242 sociocultural circumstances and experiences of individuals on the efficacy of sit-stand desks
243 as a strategy for reducing sitting and increasing PA. The two approaches to integration were
244 conducted to permit an examination and comparison of the benefits and challenges of
245 utilizing PIP in different ways.

246 The PIP stages of listing, matching, checking and pillar building were completed to
247 develop the joint displays, using google sheets. The listing stage involved listing raw data in
248 the quantitative (data) column and grouped data in the quantitative (categories) column,
249 relevant to understanding the efficacy of the intervention. We primarily organized the data
250 according to quantitative variables that underpinned our analysis, focused on change in
251 sitting, standing and physical activity during work hours and across the whole day, and
252 factors associated with these changes. For approach A, data and findings based on analyses of

253 ActivPAL and GT3X+ data for all participants was utilized, whereas for approach B, data
254 collected from a single participant was listed, including ActivPAL, GT3X+, survey and diary
255 data. Matching was then completed for both approach A and B by adding content to the
256 qualitative data and categories columns that directly related to the quantitative category in
257 that row, whether complimentary or contradictory in nature. This process was completed by
258 reading and reviewing all relevant data and findings and adding it to the appropriate column.
259 For approach A, the findings from the qualitative analysis, based on all qualitative data, were
260 initially reviewed, given that qualitative analysis had been previously undertaken, and raw
261 data was reviewed where appropriate, for example where there were limited examples of data
262 related to the ‘pillar’ within the findings. For approach B, all raw data specifically relevant to
263 the case was reviewed, i.e. observation data, interview completed; the overarching qualitative
264 findings were not considered for approach B as these did not specifically relate to the case.
265 Cells were left blank where there was no qualitative data relevant to the quantitative data for
266 any given row. Once all the data had been reviewed and inputted, the four completed
267 columns were cross-checked by the first author and reviewed by the second author and
268 revisions were made based on discussions between the two researchers. Finally, pillar
269 building was initially completed by the first author by comparing, contrasting and integrating
270 the findings from the qualitative and quantitative columns, and a final iteration was produced
271 following review and discussion between both authors. Case studies were developed by
272 narratively drawing together the content from the pillar building column of the joint displays,
273 and these are presented in the next section.

274

Findings

275

276

Herein two case studies are presented to illustrate different applications of the PIP approach to integrating mixed method findings. Both case studies focus on the efficacy of a

277 workplace intervention to reduce sitting and increase physical activity. Due to space
278 limitations, the case studies are focused on presenting certain themes from the integration
279 process, rather than presenting the entire analysis

280 **PIP Case Study A: Mixed Interpretation of Qualitative and Quantitative Findings**

281 *Workplace Sitting, Standing and Physical Activity*

282 The outcome evaluation revealed that the sit-stand desk intervention increased
283 standing during work hours in the intervention groups at 2-weeks, 3-months and 12-months.
284 Interviewees' accounts indicate that sit-stand desks can contribute to behavioural change by
285 challenging the habituated and routinely performed practice of sitting at the desk to work:

286 *"it's so obvious that it is a different desk... you're sitting at it and you sort of look*
287 *down and go 'oh yeah, I could stand up'..." (Steph, Macmillan, sit-stand desk user).*

288 The presence of a sit-stand desk (context) can disrupt habituated sitting (outcome) by
289 constantly alerting attention to the opportunity to stand (mechanism). The qualitative data
290 also highlighted strong cultural norms regarding being permanently present at the desk,
291 linked to a conflation of being at the desk with productivity (context). Within this context, a
292 sit-stand desk led to increased standing outcome) through enabling postural change without
293 compromising productivity (mechanism):

294 *Having the [sit-stand] desk would allow me to, to change positions and still do my*
295 *work and not take distraction away from work (Sean, PHE, sit-stand desk user)*

296 The outcome analysis showed that some physical activity variables were raised at the
297 2-week time point in the intervention groups, compared to the control group. In accordance,
298 some interviewees voiced that the sit-stand desk could encourage more activity around the
299 office:

300 *You are more prone, once you are standing, to think 'oh, I'll print this, and I'll quickly go and*
301 *get this' ... once you're seated behind your screen... you're just doing your own thing (Brett,*
302 *sit-stand desk user)*

303 However, this was not maintained over time and some interviewees indicated that using the
304 sit-stand desk (context) could reduce movement around the office (outcome) as standing
305 negates the need to walk away from the desk to take a break from sitting (mechanism):

306 *I've heard a couple of people say... by changing posture, that's enough... they don't actually*
307 *need to go and take a break from the desk (Carol, Macmillan, sit-stand desk user)*

308 There were no significant changes in variables that represented sustained bouts of
309 physical activity (i.e. moderate-vigorous physical activity \geq 10 minutes). Interviewee
310 accounts revealed a perceived lack of time to incorporate longer activity bouts into the
311 working day, and a view that workplace practices are misaligned with efforts to increase
312 employee physical activity:

313 *I wouldn't have the time to go to the gym for an hour... I wouldn't get everything done in my*
314 *job, so I think having a sit-stand desk means that I could incorporate some sort of low-level*
315 *activity with work, which is good (Paul, control group)*

316 *There are things and you look at them and you go that would be nice but... you can't leave at*
317 *5.30 to go and do Pilates on the fourteenth floor because actually some bugger has put a*
318 *meeting in 5 till 6... if the working practices change, those things [workplace initiatives]*
319 *would mean more (Mark, sit-stand desk user)*

320 The process data shows that workplace practices including an expectation to be
321 available for meetings over lunch (context) impeded employee engagement in structured

322 initiatives (mechanism), which helps explain the limited influence of the intervention on
323 longer bouts of activity (outcome).

324 [insert table 1 about here]

325 *Efficacy of the Multicomponent Intervention vs. Sit-Stand Desks Only*

326 The multi-component intervention did not achieve intended reach. Whilst all
327 organizational emails were delivered, only 80% of planned phone calls took place due to non-
328 response. Suboptimal reach is a contextual factor that helps explain the limited efficacy of the
329 multi-component intervention compared to the sit-stand desk only intervention. In addition,
330 interviewees voiced that, whilst the organization provided a limited selection of activities, the
331 organization did not prioritise employee wellbeing:

332 *There isn't what I would call a proper health and wellbeing programme... work on sort of*
333 *mental health was just literally putting up a poster saying take a lunch break.... it just seems*
334 *as though the more I get into the world of health the less healthy the organization seems to be*
335 *(Jade, middle-manager)*

336 Management emails that comprised the organizational-level part of the intervention conveyed
337 that the organization supports employee health. Thus, employees' views that employee health
338 provision is inadequate contradict the content of the management emails. If an intervention
339 contradicts employees' beliefs, it is unlikely to be effective (Spence, 2015). This analysis
340 indicates that employees in organizations with limited health and wellbeing provision
341 (context) do not increase workplace physical activity (outcome) because intervention content
342 is not taken seriously by employees (mechanism).

343 *Influence of Wider Research Activities*

344 Qualitative data indicates that behavioral monitoring (devices, self-report diaries) was
345 instrumental in heightening employees' awareness of, and impacted, their behavior:

346 *Filling out the diaries...it's definitely shown how lethargic most of my outside of work*
347 *activities are... It's at least planted the seed in my mind that physical activities need to be part*
348 *of your social activities (Sean, sit-stand desk user)*

349 *I was really conscious not to do extra walking, because I didn't want to like skew the results,*
350 *but over time I found that I was progressively walking more anyway and so, like I wasn't*
351 *skewing the results... because this is what I am doing, and then I think over time I've done*
352 *more. So, it influenced me in... encouraging or keeping it on my mind (Grace, control group)*

353 These findings highlight that the sit-stand desk intervention was not solely responsible
354 for employee behavioral change, as changes in physical activity were also conditioned by
355 data collection requirements. This complicates, and makes it harder to discern the degree of
356 impact of the intervention on behavior. Self-monitoring is an established behavior change
357 technique (Michie et al., 2009). Participants' explanations illustrate that monitoring (context)
358 can draw peoples' attention to their levels of sitting and PA (mechanism), which causes them
359 to contemplate, and sometimes alter, their behavior (outcome). Whilst the impact of
360 behavioral monitoring (context) is positive, participants in all three study groups partook in
361 this component of the research, it may have served to confound findings related to
362 intervention effects (outcome).

363 **PIP Case Study B: A Case-Oriented Analysis of Mixed Methods Data**

364 **'Joan'**

365 Joan was the participant 'case' selected for the case-oriented PIP case study. Joan was
366 a participant in the sit-stand desk only intervention group. At the start of the project, Joan

367 reported that she was aged between 55-59, and lived with her partner and two grown up
368 children. Her BMI was in the healthy range. She was employed in a senior role, earning over
369 £3900/month before deductions. The case example is not intended to be representative, but
370 rather, it enables detailed examination of specific demographic characteristics, sociocultural
371 circumstances and experiences of individuals on the suitability of sit-stand desks as a strategy
372 for reducing sitting and increasing standing and physical activity.

373 *Changes in Workplace Sitting and Standing*

374 Observational and interview data give the impression that, as a result of using the sit-
375 stand desk, Joan reduced sitting and increased standing at work substantially:

376 *I told the lady that I was working on the sit-stand project and she said 'what?' so Joan said*
377 *'sit-stand' and pointed to her desk. She said 'ooh, we don't think of them as sit-stand, just*
378 *standing desks, as Joan only ever stands at it!' (Research notes, 18th May 2015)*

379 *I expected to use it half the time... I use it more than that... three quarters (Interview data)*

380 However, the qualitative data contradicts ActivPAL data, which revealed an average
381 sitting reduction of only 16 minutes/day. Average post-intervention standing time equated to
382 36% of the work day. The paradox between the outcome and process evaluation data
383 facilitated further exploration of Joan's workplace sitting and standing. A prerequisite for sit-
384 stand desks to directly exert influence on behavior is that the employees are based at the desk
385 during work hours; conversely, diary, observational and interview data all indicated that Joan
386 spent a large proportion of the workday away from the desk, in meetings:

387 *It varies, you know, I'll... tomorrow I'm chairing a meeting; I'll be sitting down all day in a*
388 *different room (Interview data)*

389 *Joan did stand all day, probably for an hour before her 11am meeting, and then she was in*
390 *and out of meetings all day, in fact she was probably in meetings for almost half of the day*
391 *and thus spent half of the day sat down (Research notes, 18th May 2015)*

392 Evidence that Joan sat in meetings for a large portion of her workday provides a
393 partial explanation for the apparent contradiction between the ActivPAL data, showing
394 minimal reductions in sitting following the intervention, and the qualitative evidence
395 indicating that Joan only stands at her desk. Diary data illustrates that a particularly high
396 volume of meetings during the 3month monitoring phase confounded workplace sitting
397 reduction; average workplace sitting was only 5 minutes/day less at 3-months compared to
398 baseline. Regression analysis found a correlation between income and intervention efficacy
399 may be connected to work tasks commensurate with different levels of seniority and income.
400 This analysis indicates that employees with job roles with a high volume of meetings - often
401 more senior employees (context) may reduce sitting to a lesser extent (outcome) because they
402 spend less time at their sit-stand desk (mechanism).

403 However, attendance at meetings does not fully account for the contradiction between
404 the low increase in standing measured via ActivPAL and the claim that Joan always stands at
405 her sit-stand desk, as Joan spent around half of the day at her desk which should allow for an
406 average sitting reduction of considerably more than 15 minutes/day. Direct observations
407 helped further clarify the paradoxical findings:

408 *Towards the end of the afternoon, Joan had not put her sit-stand desk down but did sit a few*
409 *times to write under it... I noticed that Joan was actually sat down [at her desk] from about*
410 *4pm onwards (Research notes, 22nd May 2015 & 25th Nov 2015)*

411 The visibility of the sit-stand desk set at a standing height may have contributed to a
412 (false) perception amongst Joan’s colleagues that she always stood at her sit-stand desk, as
413 the researcher directly observed Joan sitting on more than one occasion.

414 In addition, Joan’s relatively high level of standing and sit-to-stand transitions at
415 baseline (164 minutes standing and 33 transitions/day, compared to 120 minutes standing and
416 27 transitions/day average across all participants) reduces the extent to which she can utilize
417 the desk to increase standing during work hours, which helps explain the limited efficacy of
418 the intervention according to the ActivPAL data. Diary and ActivPAL data indicate that high
419 baseline standing may be a consequence of attending meetings. It is probable that Joan broke
420 up sitting and increased physical activity by travelling to meetings, as the ActivPAL data
421 shows Joan was standing and moving around the time-period of self-reported attendance at
422 meetings.

423 The extent of workplace sitting reduction, measured via the ActivPAL, varied
424 between the post-intervention time points. At 6-months, Joan increased workplace sitting
425 compared to baseline levels. Joan’s 6-month diary data was commensurate with the activity
426 monitor data as all entries that refer to completing desk-based work also note that Joan is
427 sitting. Joan did not use the sit-stand desk during this monitoring period as she had sustained
428 a knee injury, that she suspected occurred whilst running, which required her to sit:

429 *Joan has injured her knee. She said that she much prefers standing (she’s said this to me so
430 many times before) but that she is being forced to sit at the moment as she is limping around
431 (Research notes, 15th July 2015)*

432 [insert table 2 about here]

457 likelihood of findings from different methods aligning. For example, activity monitor data is
458 minute-by-minute, whereas the activity diary typically only contributes one activity entry per
459 hour, which may partially explain the apparent contradiction between the data sources.
460 Consideration of integration at the design phase, as previous argued in the MMR literature
461 (e.g. Plano Clark, 2019; Haynes-Brown & Fetters, 2021) may have permitted a better ‘fit’ of
462 some data sources around variables of interest. The case studies also illustrate how
463 irreconcilable assumptions inherent within different methodological approaches can
464 contribute to divergent findings (Uprichard & Dawney, 2019); qualitative findings
465 emphasizing individuals’ experiences do not conform to change in outcome variables across
466 participants, but rather the different findings produce different types of evidence.

467 Despite well documented issues and challenges in data integration in MMR (Plano
468 Clark, 2019), it does not follow that findings generated from different methods should not be
469 compared, and the case studies evidence value in identifying conflicting data and findings
470 through applying PIP. For example, further analysis following identification of (apparently)
471 conflicting data revealed complexity regarding Joan’s workplace standing, including, for
472 example, that Joan attended frequent meetings that limited the overall impact of sit-stand
473 desk use on the total volume of standing, despite Joan infrequently sitting at the sit-stand
474 desk. This example supports the argument that the identification of unanticipated
475 inconsistencies through utilizing PIP can guide interpretation and lead to a deeper
476 understanding than when findings from different methods are analyzed and interpreted
477 separately (O’Cathain et al., 2010). Given this, data integration using PIP may be particularly
478 useful for the complex intervention field, especially in development, pilot and feasibility-type
479 work whereby development and refinement of programme theory is a priority. Our case
480 studies also highlighted the potential for PIP to help surface unintended consequences of

481 interventions that go beyond what can be determined from quantitative methods that focus on
482 pre-specified outcomes (Nobles et al., 2022). For example, case study B highlighted that the
483 visibility of Joan standing had an impact on her co-workers. Our experiences of applying PIP
484 to complex intervention evaluation illustrate the value of PIP in eliciting a more
485 comprehensive understanding through agreement, elaboration, explanation *and* contradiction
486 (Greene et al., 1989).

487 **PIP and Critical Realism**

488 Johnson et al., (2019) do not articulate the philosophical assumptions underpinning
489 their development of PIP, or the compatibility of PIP with different epistemologies. The
490 current research was underpinned by critical realism and our experiences suggest that PIP is
491 compatible with a realist philosophy. Utilization of PIP – in particular working through the
492 stages and the focus on developing meta-themes - helped integrate data and findings around
493 outcomes of interest to understand the relationship between context, mechanisms and
494 outcomes. We found it particularly useful to integrate (quantitative) regression data with
495 qualitative interview and observation data. Regression techniques may be particularly
496 appropriate for realist research, as they are inductive methods that help to categorise
497 contextual elements that influence outcomes (Mukumbang, 2023), for example, in our case,
498 income and seniority. The qualitative data helped us understand *how* these factors influenced
499 intervention outcomes, with one explanation being that more senior employees attend more
500 meetings away from their desk and thus have less opportunity to utilize the sit-stand desk, but
501 more opportunity to increase physical activity through travelling to meetings. We identified
502 and applied PIP following determination of our study design, and as such we missed
503 opportunities for closely aligning more of the data sources and independent analysis

504 procedures to facilitate integration at the analysis and interpretation stage of the research
505 (Haynes-Brown & Fetters, 2021).

506 In applying PIP to develop causal explanations, consistent with a realist approach, it
507 was important to ensure that participants' accounts were not taken as "straightforwardly true
508 representations of mechanisms" (Bonell et al., 2022); rather, PIP aided in comparing and
509 contrasting accounts that allowed us to interpret the data and develop explanations
510 underpinning intervention effectiveness. There is no universality to the outcome of an
511 intervention, as its power to elicit change is context dependent (Shearn et al., 2017;
512 Zachariadis et al., 2013) which minimizes the utility of determining intervention
513 effectiveness, without an accompanying process evaluation that can facilitate understanding
514 of causal mechanisms (Paparini et al., 2020; Warren et al., 2020). Taking a critical realist
515 approach and combining methods to conduct an outcome and process evaluation, and
516 integrating the data and findings using PIP, make it possible to identify mechanisms or
517 conditions that are instrumental in shaping the outcome of an intervention, which have more
518 utility due to being more generalizable across contexts.

519 **Thematic vs. Individual Case Approaches to Applying PIP**

520 A criterion of MMR is that integration of methods must occur at some stage during
521 the research process (Bazeley, 2012). The case studies provide illustrative evidence that both
522 thematic and individual case approaches to integration, utilizing PIP, can generate a more
523 nuanced understanding than the sum of the individual parts. A strength of the approach taken
524 in case study A is that it utilizes rigorous and recognized analytic procedures including
525 statistical analysis of outcome data and thematic analysis of process data. The findings from
526 the different components of the study can be judged based on accepted quality criteria for
527 data collection and analysis (Creswell, 2010, p. 59). Integration at the interpretation stage

528 does not interfere with the statistical analysis, and thus does not affect the strength of
529 evidence generated from the quantitative analysis when viewed in isolation. We found a
530 weakness of the approach taken in case study A to be that there was a level of discordance
531 between the outcome and process findings as, although the process findings are thematic,
532 they still represent individuals' experience, as qualitative data cannot be 'averaged' in the
533 same way as quantitative data often is (Sniehotta, Presseau, Hobbs, & Araújo Soares, 2012).

534 A strength of the approach to integration taken in case study B, is that it focuses on
535 individuals, rather than an 'average' which does not correspond to any of the participants'
536 actual experience or behavioral change (McDonald et al., 2017). The various data sources
537 intertwine more effectively as they correspond to the same subject. This approach permits
538 multiple data sources to be analyzed collectively (Baxter & Jack, 2008; O'Cathain et al.,
539 2010), which, in the present study, included activity monitor, diary, interview and
540 observational data. By integrating at the case level the mixing of methods is arguably less
541 artificial than mixing later in the process (Bazeley, 2012). Providing multiple case examples
542 was beyond the scope of this paper, however, doing so would permit investigation of within-
543 participant processes and the generalizability of conclusions (McDonald et al., 2017).

544 **Contribution to the Field of Mixed Methods**

545 The PIP approach facilitates integration of findings from qualitative and quantitative
546 data sources. Compared to general joint displays, which are visual ways of organizing mixed
547 data collection and analysis, PIP provides a process by which integration can be achieved and
548 enables the development of meta-themes. Our analyses provides evidence that the application
549 of PIP can facilitate the generation of new insights, particularly in relation to providing a
550 framework for integrating data to understand how interventions interact with context to
551 produce outcomes. PIP also facilitated the identification of discrepancies between data

552 sources, which prompted us to compare and contrast findings *within* the qualitative and
553 quantitative paradigms, i.e. working horizontally as well as vertically across the joint display.
554 For example, combining the interview data (perception that Joan is always standing at her
555 desk) with the observational data (Joan is often away from her desk attending meetings)
556 helped to make sense of the apparent contradiction between the interview and activPAL data
557 regarding Joan's level of sit-stand desk use. Utilizing MMR requires more creative means of
558 collecting, analyzing and presenting data, whereby the boundaries between qualitative and
559 quantitative are blurred. Behavioral intervention research has the potential to expand the
560 meaning of MMR beyond mixing qualitative and quantitative methods from within a
561 discipline, by drawing on both naturalistic and experimental methods to examine the social
562 and physical aspects of behavior (Sayer, 2000, p. 99). 'Qualitative' and 'quantitative' are
563 often presented as binary approaches to research, however, focusing on the distinction
564 between them can be divisive and obscure research complexity (Gorard, 2010, p. 243; Pearce,
565 2012). Subsequent to the analysis in this paper being completed, an extended PIP (ePIP)
566 method has been developed (Gauly et al., 2022). The ePIP supports our assertion that there is
567 value in integrating data across more than two data sources, and provides an updated
568 framework for better facilitating integration of data across three sources (Gauly et al., 2022).

569 A strength of this study is that it advances PIP through considering the philosophical
570 assumptions underpinning the method, evidencing the value of integrating methods within as
571 well as across the 'qualitative' and 'quantitative' categories, and by illustrating its
572 applicability to the workplace health and complex evaluation fields. The study also evidences
573 the value of integrating process and outcome evaluation findings, rather than presenting these
574 separately, and providing an illustrative example of a structured but flexible approach to
575 doing this. A limitation of the present study is that the decision to apply PIP was made

576 following data collection, rather than during the initial study conception. Had the decision
577 been made earlier, it may have been possible to adapt data collection to facilitate integration
578 of findings. For example, interviews could have specifically explored the impact of personal
579 characteristics on sit-stand desk use and physical activity, which would have related to the
580 quantitative data correlating personal characteristics with intervention outcomes. Conducting
581 an initial qualitative framework analysis on the interview and observation data may have also
582 been conducive to mixed method integration, as the matrix used as part of this method
583 permits multiple comparisons between subjects, data sources, outcomes and time points (Gale
584 et al., 2013).

585 **Conclusion**

586 This paper has discussed application of the PIP approach to integrate mixed methods
587 findings, drawing on research collected as part of a pilot RCT and process evaluation of a
588 workplace sit-stand desk intervention. Whilst researchers are increasingly employing process
589 evaluations alongside outcome evaluations interventions (Morgan-Trimmer, 2015), the two
590 components of the study are typically reported in parallel. This paper has demonstrated that
591 there is potential for integrating data from different methods utilized as part of an intervention
592 evaluation, and that PIP is a useful and flexible tool to facilitate this integration. Further
593 research applying PIP is warranted to examine the feasibility and utility of PIP for different
594 intervention and evaluation contexts and to further advance the method.

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Table 1

Extract from the Joint Display from which Case Study A was developed

Quantitative (data)	Quantitative (categories)	Pillar Building (themes)	Qualitative (categories)	Qualitative (codes)
Change in vigorous activity was 5.18 min higher in the IGs compared to the CG (p =.044), & change in MVPA was 3.36 min higher in the sit-stand desk group than the CG (p = .017) at 2wks. However, MVPA change from baseline was more	Slight increase in activity initially, but over time, activity was lower than in the CG; during work hours - no change in physical activity bouts > 10 min. Large inter - participant variation, for example, at 3mo,	No change in physical activity as mixed views about whether a sit-stand desk encourages movement - some think they don't need to move to break up sitting when using a sit-stand desk. CG has a	A perception that the sit-stand desk can encourage more activity around the office A perceived lack of time to incorporate physical activity into the working day Some workplace practices contradict organizational efforts to promote activity. For example, the expectation that employees be available to attend meetings over lunch limits opportunity to partake in organized activities	You are more prone, once you are standing, to think 'oh, I'll print this, and I'll quickly go and get this' (Brett, sit-stand desk user) I wouldn't have the time to go to the gym for an hour... I wouldn't get everything done in my job (Paul, CG) There are things and you look at them and you go that would be nice but... you can't leave at 5.30 to go and do Pilates on the fourteenth floor because actually some bugger has put a meeting in 5 till 6... if the working practices change, those things would mean more (Mark, sit-stand user) I

positive in the CG stepping varied need to move Using a sit-stand desk could reduce 've heard a couple of people say... by changing
 compared to the IGs from a 63-min away from the movement as standing negates the posture, that's enough... they don't actually need
 at 12mo (CG = increase to a 70- desk to break up need to walk away from the desk to to go and take a break from the desk (Carol, sit-
 +4.62 min, IG = - min reduction sitting. take a break from sitting stand user)
 0.16 min, $p = .025$). from baseline.

Table 2

Extract from the Joint Display from which Case Study B was developed

Quantitative (data)	Quantitative (categories)	Pillar Building (themes)	Qualitative (categories)	Qualitative (codes)
Average 16 min reduction in sitting from baseline, across all time-points Sitting minutes: 2wks -77 min reduction from baseline; 3 mo -5 min reduction from baseline;	On average, Joan increased standing and reduced sitting from baseline. However, substantial variation over time, including an increase in sitting at one	Paradox between data - qualitative shows Joan is always standing at work, whereas quantitative shows a 16 min average increase. Partly explained by large variation over time, which could have coincided with qualitative data collection. However, this facilitated further exploration of Joan's workplace sitting and standing. High levels of sitting at 6mo explained by Joan sustaining an injury confounded the	Observational and interview data give the impression that, as a result of using the sit-stand desk, Joan reduced sitting and increased standing at work substantially Joan did not use the sit-stand desk during the 6mo monitoring period as she had sustained a knee injury	I told the lady that just arrived that I was working on the sit-stand project and she said 'what?' so Joan said 'sit-stand' and pointed to her desk. She said 'oooh, we don't think of them as sit-stand, just standing desks, as Joan only ever stands at it!' (Research notes, 18th May 2015) I got the sense of 'use it as you want to', but I expected to use it half the time... I use it more than that... (Interview data) Joan has injured her knee. She said that she

6mo -77 min increase from baseline; 12 mo - 57 min reduction from baseline	time point.	potential intervention effect. This led to a decision to examine change excluding 6mo time point = 38min/day reduction in sitting, which reduces the discrepancy between data sources	which required her to sit	much prefers standing (she's said this to me so many times before) but that she is being forced to sit at the moment as she is limping around (Research notes, 15th July 2015)
Diary data (6mo example): 9-10am sitting - meeting; 12-1pm sitting - meeting; 1-2 pm sitting - meeting; 2-3pm sitting - meeting; 3-4pm sitting - meeting	Diary data illustrates that a particularly high volume of meetings during the 3mo time-point confounded workplace sitting reduction	Complementarity – majority of day in meetings provides partial explanation for apparent contradiction between ActivPAL data, showing minimal reductions in sitting, and qualitative evidence indicating Joan only stands at her desk. Additional explanation is that Joan sometimes sits whilst the desk is in the standing position	Qualitative data indicate Joan spent a large proportion of the workday away from the desk, in meetings. The visibility of the sit-stand desk set at a standing height may have contributed to a (false) perception amongst Joan's colleagues that she is always stood	It varies, you know... tomorrow I'm chairing a meeting; I'll be sitting down all day in a different room (Interview data) She told Ben that she always has it in the up [standing] position, literally never puts it down... She said that if there is something, like reading a long intensive document, that she feels she needs to sit for, then she will move to a spare desk somewhere else to do that (Research notes, 23rd April 2015)
