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Diabetes Prevention Programs: *A Review of the Evidence*

The Washington State Legislature directed the Washington State Institute for Public Policy (WSIPP) to "calculate the return on investment to taxpayers from evidence-based prevention and intervention programs and policies."[1] Additionally, WSIPP's Board of Directors authorized WSIPP to work on a joint project with the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP's benefit-cost analysis to certain health care topics.

As part of the Pew-MacArthur Results First Initiative, diabetes prevention was identified as an important health care issue for states. One important goal is to determine whether diabetes prevention programs can help states control Medicaid and other health care costs.

Within the health care setting, diabetes prevention includes "lifestyle interventions" and drug therapies. This study reviews evidence on the effectiveness of lifestyle programs designed to prevent type 2 diabetes among individuals at high risk for the disease.[2] In a subsequent report, WSIPP will present benefit-cost results for these programs.

[1] Engrossed Substitute House Bill 1244, Chapter 564, Laws of 2009.

[2] These results have been summarized in a December 2014 WSIPP report: Bauer, J., Kay, N., Lemon, M., & Morris, M. (2014). *Interventions to promote health and increase health care efficiency: A review of the evidence*, (Doc. No. 14-12-3402). Olympia: Washington State Institute for Public Policy.

Summary

WSIPP's Board of Directors authorized WSIPP to work on a joint project with the MacArthur Foundation and the Pew Charitable Trusts to extend WSIPP's benefit-cost analysis to certain health care topics. The Pew-MacArthur Results First Initiative identified diabetes prevention as an important health care issue for states. One important goal is to determine whether diabetes prevention policies can help states control Medicaid and other health care costs.

Lifestyle programs target individuals at high risk for diabetes, providing them with counseling and other support. The aim of the programs is to improve diet, increase physical activity, and reduce weight and the incidence of diabetes.

We reviewed credible research studies from the United States and elsewhere to determine whether lifestyle programs can achieve these results. We find that, on average, the programs have significant effects on diabetes incidence, weight loss, and certain risk factors for cardiovascular disease.

The clearest evidence for effects on diabetes incidence comes from clinical trials of long-term, intensive interventions with individual counseling. These programs typically reduce the risk of diabetes onset by about a half by the end of active intervention. Over time, many program participants ultimately develop diabetes but onset is reduced or substantially delayed.

For less costly group-based programs offered in a community setting, we find significant effects on weight loss, though outcomes vary across studies. The longer-term effect of these less costly programs, however, is not known.

I. Background

Diabetes Disease Burden

People with type 2 diabetes, the most common form of the disease, do not produce enough insulin or cannot use it properly (insulin resistance). Blood glucose levels rise, which damages blood vessels, nerves, and organs. Over time, two types of complications can arise. "Microvascular" complications result in blindness, kidney disease, and foot problems. "Macrovascular" complications increase the risk of heart disease and stroke. Cardiovascular disease is the leading cause of death for individuals with diabetes and a major contributor to the costs of the disease.[3]

Prevalence rates of diabetes in the US more than doubled over the last 20 years, in large part due to rising levels of obesity.[4] An estimated 29 million Americans—including 16% of adults ages 45 to 64—have diabetes.[5]

The federal Centers for Disease Control and Prevention estimate that diabetes cost the US $245 billion in 2012, including direct medical costs of $176 billion and $69 billion from indirect costs (due to disability, work loss, and early death).[6]

Medicare pays for over half of the medical costs associated with diabetes. Medicaid is also a major payer, particularly through support for individuals who are eligible for both Medicaid and Medicare (dual-eligibles).[7] Medicaid expenses are substantial, in part, because a quarter of nursing home residents have diabetes.[8]

Diabetes Management

While not the focus of our research review in this report, proper management of the disease can reduce complications and mortality.[9] Damage to the eyes, kidneys, and nerves can be reduced though intensive control of blood glucose levels at early stages of the disease.[10] The effect of intensive glucose control on cardiovascular disease is less clear. It appears to be more effective in reducing cardiovascular complications among newly diagnosed patients, rather than those with more advanced diabetes.[11] Diabetes patients also tend to have other risk factors for heart disease, such as high blood pressure and poor cholesterol levels. Controlling glucose, blood pressure, and cholesterol levels has reduced mortality among individuals with type 2 diabetes.[12]

[3] Khavandi et al., 2013; Gillett et al., 2012; Fradkin, 2012; Uusitupa et al., 2011; DeFronzo & Abdul-Ghani, 2011; Villarivera et al., 2012; American Diabetes Association, 2014; Aroda & Ratner, 2008; Matfin & Pratley, 2010; Yeboah et al., 2011; and Hajhosseiny et al., 2014.
[4] Khavandi et al., 2013 and Uusitupa et al., 2011.
[5] Centers for Disease Control and Prevention. 2014. *National Diabetes Statistics Report.*
[6] Ibid.

[7] United Health (2010) estimates that 37% of Medicare and Medicaid dual-eligibles have type 2 diabetes, with annual medical costs per case of $10,320.
[8] Fradkin, 2012.
[9] Some interventions for managing diabetic complications have also been found to be cost-beneficial. Li et al., 2010.
[10] American Diabetes Association, 2014; Fradkin, 2012; and Ryden et al., 2013.
[11] American Diabetes Association, 2014; Hajhosseiny et al., 2014; Ryden et al., 2013; Simmons et al., 2010.
[12] Fradkin, 2012 and Ryden et al., 2013.

Diabetes Prevention

Prevention—the focus of this report—is important because as diabetes progresses it becomes more difficult to manage complications.[13] Within the health care setting, diabetes prevention includes lifestyle interventions and drug therapies.[14]

We focus on evidence for the effectiveness of lifestyle programs. These programs typically target individuals with "prediabetes." People diagnosed with prediabetes have elevated glucose levels because their bodies do not use insulin effectively. Not everyone with prediabetes eventually develops the disease, but they are at high risk of doing so. One study found that 70% of people with prediabetes eventually develop the disease.[15] The overall goal of the prevention programs reviewed here is to reduce that rate.

A number of clinical trials have evaluated the effectiveness of long-term, intensive lifestyle programs with individual counseling.[16] Two of the most intensive interventions for which short- and long-term outcomes have been evaluated, are the US Diabetes Prevention Program (DPP) and the Finnish Diabetes Prevention Study (DPS).[17] More recent studies examine shorter-term, group-based counseling programs that have been developed to provide diabetes prevention at lower cost in community settings (for example, YMCAs or churches). These interventions tend to have fewer sessions and rely on group rather than individual counselling.[18] Some additional studies examine less-intensive programs with individual counseling. We examine the effects of all these programs in our meta-analysis.

[13] Fradkin et al., 2012; Khavandi et al., 2013; Griffin et al., 2011; Mannucci et al., 2013; and Hajhosseiny et al. 2014.

[14] The most commonly used drug therapy is Metformin. It has been found to be effective in diabetes prevention, and the American Diabetes Association recommends it for those at higher risk of developing the disease, especially if they fail to respond to lifestyle intervention— American Diabetes Association, 2014 and Moutzouri et al., 2011.

[15] Prediabetes may include two types of insulin resistance—impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). Up to 70% of people with prediabetes eventually develop diabetes. Villarivera et al., 2012 and Perreault et al., 2012. In 2012, an estimated 86 million in the US had prediabetes—US Centers for Disease Control and Prevention, (2014).

[16] For reviews of these and other trials, see: Baker et al., 2011; Venditti & Kramer, 2013; DeFronzo & Abdul-Ghani, 2011; Ryden et al., 2013; Orozco et al., 2008; Tabak et al., 2012; and Hopper et al., 2011.

[17] These two programs had three years of active intervention and included individual counselling sessions and supervised exercise classes.

[18] Program staffing in the lower-cost programs ranges from nurses to community lay workers.

II. Research Methods

When WSIPP carries out study assignments from the legislature to identify what works in public policy, we implement a set of standardized procedures. We analyze all high-quality studies to identify program effects. We look for research studies with strong evaluation designs and exclude studies with weak research methods. Our empirical approach then follows a meta-analytic framework to assess systematically all credible evaluations we can locate on a given topic.

Given the weight of the evidence, we calculate an average expected effect ("effect size") of a policy on a particular outcome of interest, as well as an estimate of the margin of error for that effect. An effect size measures the degree to which a program has been shown to change an outcome (such as diabetes incidence) for program participants relative to a comparison group. We describe our methods in detail in WSIPP's Technical Documentation.[19]

To identify all rigorous evaluations that have been undertaken, we searched for studies in PubMed, Google Scholar, and the Cochrane Library. The search was supplemented with citations from published systematic reviews. After examining abstracts, we conducted full reviews of 125 diabetes prevention studies, of which 44 are included in the meta-analysis. The other studies were excluded due to methodological or reporting issues. The 44 studies are based on 26 trials with a total of 4,552 intervention participants in 13 countries.[20]

[19] Washington State Institute for Public Policy (2014). *Benefit-cost technical documentation.* Olympia, WA: Author. Retrieved from http://www.wsipp.wa.gov/TechnicalDocumentation/WsippBenefitCostTechnicalDocumentation.pdf

[20] Countries include Australia, Canada, China, Finland, Germany, India, Italy, Japan (three studies), the Netherlands, Spain, Sweden (two), the UK (four), and the US (eight).

III. Meta-Analysis Findings

Diabetes incidence is the primary outcome of interest in this review. Studies also reported impacts on weight change, glucose levels, and cardiovascular risk factors.

Where possible, we report average effect sizes for (a) all programs, (b) long-term intensive programs with individual counseling, and (c) shorter-term, group-based counseling programs. The group-based programs are less costly than the more intensive, individual-based counseling programs. In a subsequent WSIPP report, we will present the results of our benefit-cost analysis to help the legislature identify the programs with the best return on investment.[21]

Outcome: Diabetes Incidence

We located 11 methodologically sound studies that report effects on diabetes incidence at the end of active intervention. Program duration and intensity vary, but these studies largely represent interventions with relatively long durations and individual counseling.[22]

The studies provide clear evidence for the effectiveness of lifestyle interventions. The average effect size on diabetes incidence is highly significant (Exhibit 1).[23] Programs typically reduce the risk of diabetes onset by about a half by the end of active intervention.

Exhibit 1

Lifestyle Program Effects on Diabetes Incidence

	Average effect size	Standard error	Number of studies	Number in treatment groups
All studies	-0.387**	0.050	11	2,812
Long-term, intensive, individual counseling*	-0.533**	0.098	2	1,344

Estimates are for the end of active intervention.

See Appendix Exhibit A1 for a description of the included studies.

* Includes the US Diabetes Prevention Program and the Finnish Diabetes Prevention Study.

** Results are statistically significant based on a p-value of < 0.001.

[21] WSIPP is currently adapting our benefit-cost model to include health care outcomes.

[22] See Appendix Exhibit A1 for individual study descriptions and program effects.

[23] Estimates use an intraclass correlation coefficient (ICC) of 0.04 to correct for participant clustering, when a study does not do so. The ICC was selected based on diabetes prevention study protocols—Gray et al., 2012; Yates et al., 2012; and Ferrara et al., 2014. Sensitivity analysis, allowing the ICC to vary between 0.02 and 0.05, indicates that estimates do not substantially change across this range of plausible ICC values.

Effects are larger for the more intensive, longer-term programs with individual counseling.[24] Unfortunately, the more recent studies that evaluate shorter-term, group-based interventions typically have short follow-up (often one year or less), and measured outcomes are often limited to weight loss. The only group-based intervention included among the studies in Exhibit 1 is the HELP-PD program evaluated by Katula et al. (2013). This study was not designed to detect effects on diabetes incidence, but reductions were observed (see Appendix Exhibit A1).

Long-term follow up results are available for three of the international trials. Program effects on diabetes incidence persist over time, but effect sizes typically decline as more of these high-risk individuals eventually experience disease onset (Exhibit 2). Despite this decline, significant reductions in incidence remain after long-term follow up. For example, the largest study in the US found that, after ten years, the incidence of diabetes was reduced from 52% for those who did not participate in the program to 42% for those who did.[25]

Exhibit 2

Program Effects on Diabetes Incidence over Time

Trial	Country	Follow-up (years)	Effect size	Percent with diabetes	
				Lifestyle group	Control group
Diabetes Prevention Program	US	3	-0.534	14%	29%
		10	-0.244	42%	52%
Diabetes Prevention Study	Finland	3	-0.525	10%	23%
		4	-0.398	18%	30%
		7	-0.340	32%	46%
		13	-0.295	49%	64%
Da Qing Diabetes Prevention Study	China	6	-0.432	43%	66%
		20	-0.340	80%	93%

Effect sizes are estimated based on data reported by Knowler et al., 2002 & 2009; Tuomilehto et al., 2001; Lindstrom et al., 2006 & 2013; and Li et al., 2008.

[24] The US Diabetes Prevention Program (DPP) and the Finnish Diabetes Prevention Study (DPS) interventions lasted three years. These were intensive interventions. The US DPP, for example, included 16 individual counseling sessions, phone contacts between sessions, and twice weekly supervised exercise classes during the first six months. This was followed by a 30-month maintenance period, with group or individual sessions every two months. The program was delivered by registered dietitians and staff with masters' degrees in exercise physiology or psychology.

[25] Knowler et al., 2009. Note that interpretation of the long-term US DPP results is complicated by fact that a group-based lifestyle program was offered to the control group after the end of original DPP. This was effective in reducing incidence among the former control participants.

Outcome: Weight Change

Weight loss is critical in preventing type 2 diabetes.[26] Seventeen studies that met the criteria for our review report results for weight change. Average weight loss varies across programs and over time within trials, due to a tendency for participants to regain weight.[27]

Exhibit 3 summarizes results for the studies that report average weight losses at (or around) 12-months follow-up.[28]

Lifestyle programs produce significant weight loss. The average effect size for shorter-term, group-based programs is smaller than that for the longer-term individual programs. However, some group-based programs have achieved weight losses comparable or close to that for the more intensive programs.[29] Participants typically lose an average of 4% to 6% of body weight in these group-based programs at 12 months follow-up. It is important to note that the existing research studies on group-based programs do not measure the long-term effects on weight loss or diabetes incidence.[30]

Exhibit 3

Diabetes Prevention Program Effects on Weight Change

Study	Follow-up (months)	Average effect size	Standard error	Number of studies	Number in treatment groups
All studies	12-15	-0.221*	0.034	12	2,457
Long-term, intensive, individual counseling	12	-0.298*	0.052	2	1,344
Shorter-term, group counseling	12-15	-0.235*	0.068	6	547

Estimates are based on studies reporting results at (or around) 12 months follow-up.
See Appendix Exhibit A2 for a list and descriptions of included studies.
* Results are statistically significant based on a p-value of < 0.01.

[26] Hamman et al., 2006 and Knowler et al., 2009.
[27] See Appendix Exhibit A2 for reported weight loss at different follow-up durations.
[28] Estimates use an intraclass correlation coefficient (ICC) of 0.02 to correct of participant clustering; based on studies by Parker et al., 2005; West et al., 2011; and Wing et al., 2014. Sensitivity analysis, allowing the ICC to vary between 0.02 and 0.04, indicates that estimates do not change substantially across this range of plausible ICC values.
[29] The DEPLOY (YMCA), HELP-PD, E-LITE programs achieved 6% or greater weight loss at 12 months. See Appendix Exhibit A2.
[30] Katula et al., 2011; Whittemore, 2011; Johnson et al., 2013; Ali et al., 2012; and Venditti & Kramer, 2013.

Outcome: Fasting Glucose

Diabetes is the result of rising blood glucose levels. Several shorter-term, group-based programs report effects for blood glucose levels, and we can compare these to results from the intensive programs with individual counseling (Exhibit 4).[31] Glucose level effects vary across the group-based studies. The average effect is significant, though smaller than that for the US Diabetes Prevention Program trial.[32]

Outcome: Cardiovascular Risk

Twelve rigorous studies report effects on several cardiovascular risk factors. Pooling the data from these studies, we find lifestyle interventions have significant beneficial effects on blood pressure, total cholesterol, and triglyceride levels (Exhibit 5).[33] The average effects for HDL and LDL cholesterol, however, were not significant.[34]

Exhibit 4

Diabetes Prevention Program Effects on Fasting Glucose Levels

Trial	Follow-up (months)	Average effect size	Standard error	Number of studies	Number in treatment groups
Long-term, intensive, individual counseling(1)	12	-0.453*	0.053	2	1344
Shorter-term, group counseling(2)	6-15	-0.292*	0.074	7	763

* Results are statistically significant based on a p-value of < 0.01.
Studies included in the meta-analysis:
(1) Haffner et al., 2005 and Tuomilehto et al., 2001.
(2) Katula et al., 2011; Mason et al., 2011; Moore et al., 2011; Parikh et al., 2010; Ockene et al., 2012; Ma et al., 2013; and Kulzer et al., 2009.

[31] Estimates use an intraclass correlation coefficient (ICC) of 0.02 to correct of participant clustering; based on studies by Parker et al., 2005 and Littenberg & MacLean 2006. Sensitivity analysis, allowing the ICC to vary between 0.02 and 0.06, indicates that estimates do not change substantially across this range of ICC values.

[32] Four group-based counseling studies report results for glycated hemoglobin (HbA1c), a measure of average plasma glucose concentration over prolonged periods. Across these studies, programs have a marginally significant effect (with an average effect size of -0.183 and p-value of 0.059). The studies include: Ackermann et al., 2008, Parikh et al., 2010, Ockene et al., 2012, and Kulzer et al., 2009.

[33] Estimates use an intraclass correlation coefficient (ICC) of 0.04 for most outcomes to correct for participant clustering—Parker et al., 2005; Littenberg & MacLean, 2006. Exceptions were the ICCs for HDL cholesterol (0.01) and triglycerides (0.02). Sensitivity analysis, allowing ICCs to vary across a plausible range, were performed for diastolic blood pressure and HDL cholesterol.

[34] These findings are consistent with published reviews. See: DeFronzo & Abdul-Ghani, 2011; Orozco et al., 2008; and Orchard et al., 2013.

Exhibit 5

Diabetes Prevention Program Effects on CVD Risk Factors

	Average effect size	Standard error	Number of studies	Number in treatment groups
Diastolic blood pressure[(1)]	-0.112	0.046*	11	2,539
Systolic blood pressure[(2)]	-0.100	0.041*	12	2,568
Total cholesterol[(3)]	-0.128	0.050*	8	1,280
HDL cholesterol[(4)]	0.068	0.050	8	916
LDL cholesterol[(5)]	-0.030	0.054	6	1,349
Triglycerides[(6)]	-0.193	0.041*	6	1,857

* Results are statistically significant base on a p-value of < 0.015.

Studies included in meta-analyses:

(1) Bhopal et al.,2014; Kulzer et al., 2009; Li et al.,2008: Lindstrom et al., 2003: Ma et al., 2013; Oldroyd et al., 2001; Parikh et al., 2010; Ratner et al., 2005; Roumen et al., 2008; Saito et al., 2011; and Wing et al.,1998.

(2) Ackermann et al., 2008; Bhopal et al., 2014; Kulzer et al., 2009; Li et al., 2008; Lindstrom et al., 2003: Ma et al., 2013; Oldroyd et al., 2001; Parikh et al., 2010; Ratner et al., 2005; Roumen et al., 2008; Saito et al., 2011; and Wing et al.,1998.

(3) Ackermann et al., 2008; Kulzer et al., 2009; Li et al., 2008: Lindstrom et al., 2003: Ma et al., 2013; Oldroyd et al., 2001; Saito et al., 2011; and Wing et al.,1998.

(4) Ackermann et al., 2008; Kulzer et al., 2009; Lindstrom et al., 2003: Ma et al., 2013; Oldroyd et al., 2001; Roumen et al., 2008; Saito et al., 2011; and Wing et al.,1998.

(5) Ma et al., 2013; Oldroyd et al., 2001; Parikh et al., 2010; Ratner et al., 2005; Roumen et al., 2008; and Wing et al., 1998.

(6) Lindstrom et al., 2003; Kulzer et al., 2009; Ma et al., 2013; Ratner et al., 2005; Saito et al., 2011; and Wing et al.,1998.

Other Outcomes: Strokes, Heart Attacks, and Mortality

While we found evidence that lifestyle programs can reduce diabetes incidence and certain cardiovascular risk factors, we searched for, but did not locate, sufficient evidence regarding the impact of these programs on cardiovascular disease (e.g., strokes and heart attacks) and mortality. It is not yet clear what effects diabetes prevention programs have on these outcomes.

Given the lags between program enrollment, diabetes onset, and the appearance of complications, it could take decades to observe effects on cardiovascular disease. We found only three diabetes prevention evaluations that report long-term cardiovascular disease and mortality outcomes—one study for the Finnish Diabetes Prevention Study (DPS) and two for the Chinese Da Qing Diabetes Prevention Study (DQS).[35] Uusitupa et al. (2009) examined participants in the Finnish DPS ten years after program recruitment. They did not find significant lifestyle

[35] Knowler et al., (2009) examined outcomes for US Diabetes Prevention Program participants ten years after recruitment. The authors concluded that cardiovascular complications were too infrequent over the ten years for an analysis of treatment effects.

program effects on cardiovascular disease or mortality.[36] Li et al. (2008) also failed to find significant effects on these outcomes for Chinese DQS participants after 20 years of follow-up.[37] A more recent study (Li et al., 2014), which examined DQS participants after 23 years, reported significant effects on cardiovascular and all-cause mortality—but the effects were significant only for women.[38]

IV. Conclusions

We find that, on average, lifestyle interventions have significant beneficial effects on diabetes incidence, weight loss, blood glucose levels, and certain cardiovascular risk factors.

WSIPP's benefit-cost model for these diabetes prevention programs is forthcoming.

[36] Based on reported outcomes in Uusitupa et al., (2009), we estimate program effect sizes of 0.025 (p-value 0.904) for cardiovascular disease and -0.131 (p-value 0.526) for all-cause mortality.

[37] Based on reported outcomes in Li et al., (2008), we estimate program effect sizes of -0.014 (p-value 0.917) for cardiovascular disease, -0.076 (p-value 0.557) for cardiovascular mortality, and -0.023 (p-value 0.859) for all-cause mortality.

[38] Based on reported outcomes in Li et al., (2014), we estimate program effect sizes of -0.239 (p-value 0.068) for cardiovascular mortality and -0.229 (p-value 0.080) for all-cause mortality. Note that the DQS study population had especially high diabetes prevalence (Exhibit 2) and the results may have limited applicability to the US population (Selph et al., 2014). For discussions of these studies, see: Tabak et al., 2012; Hopper et al., 2011; Khavandi et al., 2013; Uusitupa, Tuomilehto & Puska, 2011; Matfin and Pratley, 2010; Fradkin et al., 2012; Mannucci et al., 2013; DeFronzo & Abdul-Ghani, 2011; Orchard et al., 2013; and Selph et al., 2014.

Appendix

Diabetes Prevention Program: A Review of the Evidence

A1. Program Descriptions and Study-Level Results

Diabetes Incidence

Exhibit A1

Program Characteristics and Effects on Diabetes Incidence

Citation	Trial	Study location	Program duration (years)	Intervention intensity	Follow-up (years)	Effect size	Percent with Diabetes		Number in
							Treatment groups	Control groups	Treatment group
Knowler et al. 2002	US Diabetes Prevention Program	US	3	**Months 1-6:** 16 individual sessions, twice weekly exercise sessions offered. **Months 7+**: group or individual session every two months, supervised exercise	3	-0.534	14.4%	28.9%	1079
Tuomilehto et al., 2001	Finnish Diabetes Prevention Study	Finland	3	**Months 1-12:** 7 individual sessions with nutritionist, supervised exercise session. **Months 13+:** individual sessions with nutritionist every 3 months, supervised exercise sessions offered	3	-0.525	10.2%	23.0%	265
Li et al., 2008	Da Qing Diabete Prevention Study	China	6	**Month 1:** 1 individual counseling session, 4 group sessions. **Months 2-4:** monthly group sessions. **Months 5-72:** group sessions every 3 months	6	-0.432	42.8%	65.8%	438
Katula et al., 2013	HELP-PD	US	2	**Months 1-6:** weekly groups sessions with community health worker, 3 individual sessions with dietician. **Months 7+:** 2 contacts per month with health worker (1 group, 1 phone)	2	-0.329	3.0%	8.7%	151
Roumen et al., 2008	SLIM Study	Netherlands	3	**Months 1 -36:** individual sessions with dietitian every 3 months, aerobic and resistence training	3	-0.460	18.0%	32.0%	74
Penn et al., 2009	European DP RCT Newcastle upon Tyne	UK	3	**Months 1-3:** Individual sessions with dietitian and physiotherapist every month. **Months 3+:** individual sessions with dietitian and physiotherapist every 3 months; occasional group sessions	3	-0.438	9.8%	21.6%	51
Bhopal et al., 2014	Prevention of Diabetes in South Asians	UK	3	**Months 1-36:** 15 home visits by dietitian	3	-0.247	15.0%	21.0%	85
Ramachandran et al., 2006	Indian Diabetes Prevention Program	India	3	**Months 1-36:** individual counseling sessions every 6 month intervals, monthly phone contacts	3	-0.384	39.3%	55.0%	133
Saito et al., 2011	Zensharen Study for Prevention of Lifestyle Diseases	Japan	3	**Months 1-36:** 9 individual counseling sessions with medical staff (at 0,1,3,6,12,18,24,30 and 36 months)	3	-0.218	12.2%	16.6%	311
Sakane et al., 2011	Japan Diabetes Prevention Program	Japan	3	**Months 1-12:** 4 group sessions, 2 individual counseling sessions, monthly faxes. **Months 13-36:** 2 individual sessions per per year	3	-0.278	8.2%	14.8%	123
Kosaka et al., 2005	Toranomon Hospital Study	Japan	1	**Months 1-12:** individual diet and exercise counseling every 2-3 months	4	-0.262	3.0%	9.3%	102

Exhibit A2

Program Characteristics and Effects on Weight Loss

Citation	Trial/study	Study location	Program duration (months)	Intervention intensity	Follow-up (months)	Effect size	Intervention group weight loss
Long-term, intensive, individual counseling							
Haffner et al., 2005	US Diabetes Prevention Program	US	36	**Months 1-6:** 16 individual sessions, twice weekly exercise sessions offered. **Months 7+**: group or individual session every two months, supervised exercise	12	**-0.309**	7.2%
Knowler et al., 2002					36	**-0.268**	6.0%
Knowler et al., 2009					120	**-0.073**	2.6%
Lindstrom et al., 2003	Finnish Diabetes Prevention Study	Finland	36	**Months 1-12:** 7 individual sessions with nutritionist, supervised exercise session. **Months 13+:** individual sessions with nutritionist every 3 months, supervised exercise sessions offered	12	**-0.246**	5.2%
Lindstrom et al., 2003					36	**-0.182**	4.0%
Li et al., 2008	Da Qing Diabetes Prevention Study*	China	72	**Month 1:** 1 individual counseling session, 4 group sessions. **Months 2-4:** monthly group sessions. **Months 5-72:** group sessions every 3 months	72	**-0.167**	2.7%
Shorter-term, group counseling							
Ackermann et al., 2008	DEPLOY (YMCA)	US	5	**Months 1-5:** 16 group sessions	5	**-0.224**	6.0%
Ackermann et al., 2008					13	**-0.234**	6.0%
Katula et al., 2011	HELP-PD	US	12	**Months 1-6:** weekly groups sessions with community health worker, 3 individual sessions with dietician. **Months 7+:** 2 contacts per month with health worker (1 group, 1 phone)	12	**-0.322**	7.4%
Katula et al., 2013					24	**-0.289**	5.9%
Ma et al., 2013	E-LITE	US	15	**Months 1-3:** 12 group sessions. **Months 4-15:** secure e-mail contact every 2-4 weeks (personalized feedback on progress)	15	**-0.215**	6.6%
Xiao et al., 2013					24	**-0.165**	5.8%
Ockene et al., 2012	Lawrence Latino Diabetes Project	US	12	**Months 1-12:** 3 individual sessions (held in home), 13 group sessions	12	**-0.339**	1.3%
Parikh et al., 2010	Project HEED	US	3	**Months 1-3:** 8 group sessions	12	**-0.094**	3.2%
Kulzer et al., 2009	PREDIAS	Germany	10	**Months 1-2**: 8 group lessons. **Months 3-10:** 4 group booster lessons	12	**-0.136**	4.1%
Moore et al., 2011	Healthy Living Course*	Australia	6	**Months 1-6:** 1 individual session, 6 group sessions	6	**-0.113**	3.2%
Other studies							
Bhopal et al., 2014	Prevention of Daibetes in South Asians	UK	36	**Months 1-36:** 15 home visits by dietitian	12	**-0.041**	1.2%
Bhopal et al., 2014					36	**-0.081**	1.3%
Kosaka et al., 2005	Toranomon Hospital Study*	Japan	12	**Months 1-12:** individual diet and exercise counseling every 2-3 months	48	**-0.072**	na
Mensink et al., 2003	SLIM Study	Netherlands	36	**Months 1-12:** 5 individual and 1 group session; access to exercise training sessions (1 hour per week encouraged). **Months 13-24:** 3 individual and 1 group session. **Months 25-36:** 3 individual and 1 group	12	**-0.190**	3.1%
Roumen et al., 2008					36	**-0.332**	1.2%
Oldroyd et al., 2001	Newcastle Upon Tyne Study*	UK	6	**Months 1-6:** individual consellling by dietition and physiotherapist, 6 shorter review sessions	6	**-0.128**	1.7%
Saito et al., 2011	Zensharen Study for Prevention of Lifestyle Diseases	Japan	36	**Months 1-36:** 9 individual counseling sessions with medical staff (at 0,1,3,6,12,18,24,30 and 36 months)	12	**-0.132**	3.4%
Sakane et al., 2011	Japan Diabetes Prevention Program	Japan	36	**Months 1-12:** 4 group sessions, 2 individual counseling sessions, monthly faxes. **Months 13-36:** 2 individual sessions per per year	12	**-0.049**	2.2%
					36	**-0.031**	2.8%
Wing et al., 1998	Single study trial*	US	24	**Months 1-6:** weekly group meetings. M**onths 7-12:** biweekly group meetings. M**onths 13-24:** 2 6-week refresher courses offered	6	**-0.545**	10.4%
Wing et al., 1998					24	**-0.136**	2.5%

* Not included in the 12-month results meta-analysis due to timing of follow-up.

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