

Drug Class	Sulfonylureas		TZDs		Meglitinides	DDP-4 Inhibitors	GLP-1 Agonists (Subcut)	SGLT-2 Inhibitors	Insulin in T2DM			
Generic → BRAND	Metformin (MF) GLUCOPHAGE, GLYCON	Glipizide DIAMICRON [Glipizide GLUCOTROL USA SPREAD-DIMCAD]	Glyburide DIABETA	Pioglitazone ACTOS	Rosiglitazone AVANDIA	Acarbose GLUCOBAY	Repaglinide GLUCONORM Nateglinide STARLIX D/C	Saxagliptin ONGLYZA Sitagliptin JANUVIA Alogliptin NESINA Linagliptin TRAJENTA	Liraglutide VICTOZA Exenatide BYETTA Dulaglutide TRULICITY Lixisenatide ADLYXINE, LYXUMIA Semaglutide, Albiglutide EPERZAN D/C	Empagliflozin JARDIANCE Canagliflozin INVOKANA Dapagliflozin FORXIGA / FARXIGA Ertugliflozin STEGLATRO	Intensity: Less (NPH HS + MF)	Intensity: More (Multiple daily doses)
Major trials to support findings/Outcomes*	UKPDS-33,34,80 (ADOPT; some use in ADVANCE)	ADVANCE	UKPDS-33,80 (ADOPT)	ProACTIVE Ferwana M. Meta-analysis 2013. SR-Liao 2017, IRIS	Meta-analysis. RECORD interim, ADOPT, DREAM	ACE (Prevention trial: Stop-NIDDM)	-	SAVOR-TIMI 53 TECOS, EXAMINE PROLOGUE, CARMELINA (2018) CAROLINA (2019)	LEADER, SUSTAIN-6, ELIXA, EXSCEL, REWIND (2018), PIONEER (2018), HARMONY (2019)	EMPA-REG, CANVAS, CREDECE, DECLARE (2019), VERTIS CV (2019), DAPA-HF (2019), DAPA-CKD (2020), EMPEROR-Reduced & Preserved (2020), EMPA-Kidney (2022)	T2DM UKPDS-33,80; ADVANCE, ACCORD, VADT, ORIGIN, DEVOTE (11DM: DCCT/EDIC) (Also Boussageon et al. Meta-analysis. BMJ 2011;343:d4169)	
↓ Risk of Death / Major CV ¹	✓✓✓ ² in obese, ↓ mortality NNT=14/10y ↓ MI NNT=14/10y (UKPDS-34)	✓3,4,5 X? ^{5,6} glipizide ↑ MACE vs MF NNH=10/5yr (SPREAD-DIMCAD)	✓4,5	✓✓✓ ⁷ ↓ MACE =50/2.9yr, but 1 ^o composite NS (ProACTIVE) ↓ MACE (IRIS) (pts with insulin resistance & recent CVA/TIA)	X? ⁸	✓✓ ⁹ in IFG, ↓ MACE NNT=40/3.3yr; in established CVD (Chinese) NS	?	✓ ¹⁰ saxagliptin, alogliptin, sitagliptin ↔ non-inferior to placebo for MACE, But see ?HF below ? ¹¹ (linagliptin ongoing). Sitagliptin ↔ no effect on intima-media thickness PROLOGUE	✓✓✓ ¹² liraglutide ↓ MACE NNT=53/3.8yr (North American subgroup neutral), ↓ mortality NNT=72/3.8yr (LEADER), semaglutide SC wkly ↓ MACE NNT=44/2yr (SUSTAIN-6)	✓✓✓ ¹⁵ empagliflozin ↓ MACE NNT=63/3.1yr, ↓ mortality NNT=39/3.1yr (EMPA-REG) canagliflozin ↓ MACE NNT=220/yr (CANVAS) but mortality NS & ↑ MACE 1 st 30d (n=13 vs n=1, p=NS) ^{interim analysis}	✓✓✓ ^{17,18}	✓ ^{18,19,20} X? ²¹ > insulin use with intensive target vs standard therapy, ↑ all-cause death NNH=95/3.5yr, & CV death NNH=125/3.5yr (ACCORD)
Effect on A1C**	✓✓✓	✓✓✓	✓✓✓	✓✓	✓✓	✓	✓✓✓	✓	✓✓	✓✓	✓✓	✓✓✓
Weight (loss vs neutral vs gain)	✓✓✓ ^{A1}	X ^{A2}	X ^{A2}	XX ^{A3}	XX ^{A4}	✓✓ ^{A5}	X ^{A6}	✓ ^{A7}	✓✓✓ ^{A8}	✓✓✓ ^{A9}	✓ ^{A10}	XX ^{A10}
↓ Risk of Hypoglycemia	✓✓✓	? If less risk with MR formulation	X Severe, occurs at 1.4%/yr	✓✓ Low risk with monotherapy	✓	✓✓✓	✓✓✓	✓✓?	✓✓?	✓✓	✓	XX Rate of 1.8%/yr
↓ Risk of HF / Edema	✓✓✓ ^{22,23} 1st line in HF with eGFR >30 mL/min (CDA'13)	✓ ^{23,24} (↑ CHF risk)	✓ ^{23,25} (↑ CHF risk)	XX ²⁶ ↑ HF NNH=50/2.9yr, edema NNH=8/2.9yr	XX ^{25,27} ↑ HF NNH=69/5.5yr, (RECORD), ↑ HF NNH=250/3yr (DREAM)	✓ ²⁸	✓ ²⁹	X? ³⁰ ↑ HF saxagliptin NNH=143/2.1yr (SAVOR), alogliptin (post hoc) (EXAMINE) sitagliptin HF neutral	✓ ³¹ liraglutide (LEADER) and lixisenatide (ELIXA) neutral	✓ ³² empagliflozin ↓ HF hospitalizations (EMPA-REG) & canagliflozin but exploratory (CANVAS); (EMPEROR-Reduced & Preserved; DAPA-HF ongoing)	✓ ^{33,34} (?↑ CHF risk)	✓ ³⁴ (↑ CHF risk)
Effect on GI tolerability	X Start low & titrate	✓✓	✓✓ rate of 1.8%/yr	✓✓	✓✓	XX	✓✓	✓✓	✓ Nausea, vomiting, diarrhea	✓ Nausea/diarrhea with dapagliflozin	✓✓✓	✓✓✓
Cost	✓✓✓	✓✓✓	✓✓✓	X	X	✓✓	✓✓	X	XX	X	✓	XX
Other	May have to hold or ↓ dose in acute illness/HF/renal dysfx (? lactic acidosis); may ↓ B12. 1 st line for obese T2DM (UKPDS-34)	Used in combination with metformin (ADVANCE)	Caution: ↓ renal function (& older adults)	X FDA +/- HC warnings: ³⁵ ?↑ HF (see above), ?↑ fractures (NNH=30/~3.5y) ?↑ macular edema (conflicting data) Pio: ?↑ bladder ca >12 mos (27.5 excess /100,000 person yrs), avoid co-admin with dapagliflozin ³⁶ Rosi: Restricted access in CDN (SK-EDS) (↑ CV risk concerns) ³⁷	✓✓ PPG, Possible benefit of laxative effect in some	✓✓ PPG, flexibility with meals	✓ PPG FDA +/- HC warning: ³⁸ HF (saxa & alogliptin); arthralgia, hypersensitivity rx, ?↑ pancreatitis (ARI 0.13%), ³⁹ pancreatic cancer ⁴⁰ Linagliptin: no renal dose adjustment	✓ PPG injection site irritation ?↑ pancreatitis, ³⁹ pancreatic cancer, ⁴⁰ ?↑ thyroid cancer (liraglutide) ⁴¹ (new once weekly agents may have ↓ GI adverse events) ⁴² ?gallbladder disease ⁴⁶	X new agents – outcome & safety data still limited FDA +/- HC warning: ↑ ketoacidosis (DKA); ↑ AKI (caution: ↓ intravascular volume & renal fnx (Cana + Dapa), ↓ BP; ↑ (HR ~2) limb amputations ^{Cana,43} ↑ urosepsis/pyelonephritis, (UTI OR 1.34 & genital tract infection OR 3.5 vs placebo), ⁴⁴ ↑ fracture (HR 1.3)/↓ BMD ^{Cana} ; dapagliflozin ?↑ bladder/ breast cancer (avoid with pioglitazone) ⁴⁵	✓	✓✓ PPG Fear/perception of insulin injections	✓✓ PPG Fear/perception of insulin injections
Overall	✓✓✓?	✓✓	✓	✓?	X?	✓	✓	✓?	? ✓✓ Liraglutide (CV+mortality benefit)	? ✓✓ Empagliflozin (CV+mortality benefit)	✓✓	✓✓ X?

*Drugs that lower blood glucose come with various levels of evidence regarding their balance of benefits & harms. This chart relies on current evidence, especially from randomized controlled trials that have evaluated patient oriented outcomes. Direct comparisons between agents have not been done so one is left to evaluate each drug for its relative advantages & disadvantages. **A1C will vary depending on dose, combinations & initial A1C.
See full version of this ANTI-HYPERGLYCEMIC DIABETES AGENTS: Outcomes Comparison Summary Table online for additional notes: <http://www.rxfiles.ca/rxfiles/uploads/documents/Diabetes-Agents-Outcomes-Comparison-Summary-Table.pdf>
See also: RxFiles Diabetes Landmark Trials Summary at: <http://www.rxfiles.ca/rxfiles/uploads/documents/CDT-Diabetes-Landmark-Trials-Links.pdf> Diabetes Oral Agents Comparison Chart: <http://www.rxfiles.ca/rxfiles/uploads/documents/members/cht-diabetes.pdf>

An Advantage ✓✓✓	✓✓	Neutral ✓	X	A Disadvantage XX	Unknown/Ongoing ?
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Individualize approach considering balance of potential benefits & harms. Over-aggressive pursuit of targets can ↑ mortality. ACCORD

Death/MACE (MACE: Major adverse cardiovascular event)

1. Drug manufacturers must establish CV safety (one-sided upper boundary of 95% CI ≤ 1.3) vs comparator (typically placebo) in a RCT for all new agents in \uparrow CV risk patients.^{1 FDA}
2. Metformin vs conventional diet; obese $>120\%$ IBW & small sample $n=753$; \downarrow **all-cause mortality NNT 14/10.7 yr**, and \downarrow **MI NNT=14/10.7 yr**.^{2 UKPDS-34} 10 yr observational follow-up \downarrow **all-cause mortality NNT=14/~20 yr**, and \downarrow **MI NNT=16/~20 yr**.^{3 UKPDS-80}
3. Intensive HbA1c target (included gliclazide) vs standard HbA1c target; MACE 10% vs 10.6% $p=NS$, all-cause mortality 8.9% vs 9.6% $p=NS$.^{4 ADVANCE}
4. Intensive therapy (chlorpropamide, glipizide^{USA}, glibenclamide or insulin) vs conventional diet; all-cause mortality 17.9% vs 18.9% $p=NS$, MI 14.7% vs 17.4% $p=NS$, and stroke 5.6% vs 5% $p=NS$.^{5 UKPDS-33} 10 yr observational follow-up \downarrow **all-cause mortality NNT=29/~20 yr**, and \downarrow **MI NNT=36/~20 yr**.^{3 UKPDS-80}
5. SU (2nd or 3rd generation) vs control (diet, placebo, other antihyperglycemic); all-cause mortality OR 1.12 (0.96-1.3, $I^2=0\%$), CV mortality OR 1.12 (0.87-1.42, $I^2=12\%$), MI OR 0.92 (0.76-1.12, $I^2=NR$), stroke OR 1.16 (0.81-1.66, $I^2=NR$).⁶
6. Metformin vs glipizide; Chinese, small sample $n=304$, & medically undertreated 100% CAD, but $\leq 10\%$ taking ACEi; Metformin \downarrow **MACE NNT=10/5 yr**.^{7 SPREAD-DIMCAD}
7. Pioglitazone vs placebo; T2DM & high CV risk; \downarrow **MACE NNT=50/2.9 yr**,^{8 PROACTIVE} insulin resistance & recent TIA/stroke; \downarrow **MACE NNT=36/4.8 yr**.^{9 IRIS}
8. Rosiglitazone vs placebo; \uparrow **MACE 2.9% vs 2.1% $p=0.08$ (NS)**, trial stopped 5 mons early,^{10 DREAM} \uparrow MI $NNH=167$ & CV death 0.87% vs 0.39% $p=0.06$.¹⁰ Rosiglitazone vs glyburide \uparrow **MACE NNH 63/4 yr**.^{12 ADOPT}
9. Acarbose vs placebo; impaired glucose tolerance; \downarrow **MACE NNT 40/3.3 yr**.^{13 STOP-NIDDM} Acarbose vs placebo; coronary heart disease (Chinese) HR 0.98 95% CI, 0.86-1.11, $p=0.73$.^{13 ACE}
10. Saxagliptin vs placebo; MACE 7.3% vs 7.2%, **non-inferior** ($p<0.001$), but not superior ($p=0.99$).^{14 SAVOR-TIMI 53} Alogliptin vs placebo; MACE 11.3% vs 11.8%, **non-inferior** ($p<0.001$), but not superior ($p=0.32$).^{15 EXAMINE} Sitagliptin MACE vs placebo; MACE 9.6% vs 9.6%, **non-inferior** ($p<0.001$), but not superior ($p=0.65$).^{16 TECOS} Meta-analysis^(SAVOR-TIMI 53, EXAMINE, TECOS) MACE RR 0.99 (95% CI, 0.93-1.06, $I^2=0\%$).¹⁷
11. Linagliptin CV trial ongoing, estimated completed 2018.^{18 CARMELINA}
12. Liraglutide vs placebo; **MACE 13% vs 14.9%**, **superior** ($p=0.01$, **NNT=53/3.8 yr**), but results neutral in North America subgroup; \downarrow **CV death NNT=77/3.8 yr** and \downarrow **all-cause mortality NNT 72/3.8 yr**.^{19 LEADER} Semaglutide SC weekly vs placebo; MACE **superior**; (nephropathy was better; however, retinopathy complications were worse).^{20 SUSTAIN6}
13. Lixisenatide vs placebo (post-ACS); MACE 13.4% vs 13.2%, **non-inferior** ($p<0.001$), but not superior ($p=0.81$).^{21 ELIXA}
14. Exenatide extended release vs placebo (~70% CVD, ~30% primary prevention); MACE 11.4% vs 12.2% over median 3.2 yr, **non-inferior** ($p<0.001$), but not superior ($p=0.06$).^{22 EXSCEL} Dulaglutide^{USA} CV trial ongoing, estimated completed 2018.^{23 REWIND} Albiglutide CV trial ongoing, estimated completed 2018.^{24 HARMONY} Semaglutide PO CV trial ongoing, estimated completed 2018.^{PIONEER}
15. Empagliflozin vs placebo; **MACE 10.5% vs 12.1%**, **superior** ($p=0.04$, **NNT=63/3.1 yr**); \downarrow **CV death NNT=46/3.1 yr** and \downarrow **all-cause mortality NNT 39/3.1 yr**.^{25 EMPA-REG} Canagliflozin vs placebo; **MACE 26.9/1000ptys (2.7%/yr) vs 31.5/1000ptys (3.15%/yr)**, **superior** ($p=0.02$, **NNT~220/yr**), f/u duration 3.6yr, no significant difference in components of primary composite or death; \uparrow MACE in 1st 30 days ($n=13$ vs $n=1$, $p=NS$, non-dose related); \downarrow MACE (NS) after 30 days (HR 0.89, 95% CI 0.64, 1.25); numeric imbalance not present in non-CANVAS trials.^{26,27,28 CANVAS}
16. Dapagliflozin CV trial ongoing in primary prevention population, estimated completed 2019.^{28 DECLARE} Ertugliflozin CV trial ongoing, estimated completed 2019.^{29 VERTIS CV} Sotagliflozin CV trial ongoing, estimated completed 2022.^{SCORE}
17. Basal insulin (glargine) vs standard care; all-cause mortality 15.2% vs 15.4% $p=NS$, MI 5.4% vs 5.2% $p=NS$, and stroke 5.3 vs 5.1% $p=NS$.^{30 ORIGIN}
18. Basal insulin vs basal/bolus insulin; small sample $n=152$; CV mortality 3.8% vs 6.7% $p=NS$, MACE 20% vs 32% $p=NS$.³¹
19. Intensive insulin vs standard insulin; T1DM population; ~11 yr observational follow up \downarrow **MACE NNT=23/~17 yr**.^{32 DCCT, 33 EDIC}

Death/MACE (MACE: Major adverse cardiovascular event)- cont'd

- $p=NS$, and stroke 5.4% vs 5.0% $p=NS$.^{5 UKPDS-33} 10 yr observational follow-up \downarrow **all-cause mortality NNT=29/~20 yr**, and \downarrow **MI NNT=36/~20 yr**.^{3 UKPDS-80}
21. Greater insulin use (any & bolus) with intensive therapy vs standard therapy; \uparrow **MACE NNT=33/3.5 yr** and \uparrow **CV death NNT=125/3.5 yr**.^{34 ACCORD}
 22. Insulin degludec vs insulin glargine (T2DM; ~50/50 split bolus vs bolus/basal baseline & no difference between basal/bolus insulin use between groups at the end of study): MACE 8.5% vs 9.3% (95% CI 0.78- 1.06; $p<0.001$ non-inferiority).^{34a DEVOTE}

Weight (weight gain/loss variable, diabetic agents used in conjunction with diet and lifestyle interventions as well as other concomitant medications)

- A1. Metformin: \downarrow 2.9 kg/4 yr ^{1 ADOPT}
- A2. Sulfonylureas: \uparrow 1.6 kg/4 yr ^{1 ADOPT}
- A3. Pioglitazone: \uparrow 3.6 kg/3 yr ^{2 PROACTIVE}
- A4. Rosiglitazone: \uparrow 4.8 kg/4 yr; rosiglitazone statistically significant \uparrow weight vs. both metformin & glyburide ^{1 ADOPT}
- A5. Acarbose: \downarrow 1.15 kg/3 yr ^{3 STOP-NIDDM}
- A6. Repaglinide: \uparrow ~1.7 kg/12-24 wks;^{4,5} nateglinide: \uparrow 0.7-1 kg/16-24 wks^{4,6}
- A7. DDP4-inhibitors (generally considered neutral)⁷
 - saxagliptin \downarrow 0.4 kg/2.1 year (similar to placebo) ^{8 SAVOR-TIMI 53}
 - alogliptin \uparrow 1 kg/18 months (similar to placebo) ^{9 EXAMINE}
 - sitagliptin \uparrow ≤ 0.5 kg/12 weeks¹⁰
- A8. GLP-1 agonists
 - exenatide \downarrow 2.8 kg/24-52 weeks¹¹
 - liraglutide \downarrow 2.3 kg/3.8 yr ^{12 LEADER}
 - dulaglutide \downarrow 1.3-3 kg/5-52 weeks¹³
- A9. SGLT2 inhibitors¹⁴
 - canagliflozin \downarrow 2.8-4 kg/4-52 weeks^{15,16 CANTATA-M}
 - dapagliflozin \downarrow 2 kg/12-52 weeks¹⁷
 - empagliflozin \downarrow ~1.5-2 kg/3.1 yr^{18 EMPA-REG}
- A10. Insulin
 - intensive therapy vs standard therapy; avg weight \uparrow 3.5 kg vs 0.4 kg/3.5 yr; weight \uparrow >10 kg 28% vs 14% $p<0.001$ ^{19 ACCORD}
 - Note: detemir -1.27 to -0.8 kg vs NPH (glargine no difference vs NPH)²⁰

HF/Edema

22. MF should be considered 1st line in HF patients with eGFR > 30 mL/min [Grade D, Consensus].^{1 CDA¹³}
23. Retrospective cohort ($n=10,920$ patients hospitalized with HF); MF vs SU \downarrow **all-cause mortality aHR 0.85 (95% CI 0.75-0.98)**, MF + SU vs MF \downarrow **all-cause mortality aHR 0.89 (95% 0.82-0.96)**, MF + insulin vs SU neutral aHR 0.96 (95% CI 0.82-1.13), MF+SU+insulin neutral aHR 0.94 (0.77-1.15).²
24. Intensive A1C target (included gliclazide) vs standard A1C target; HF (HF death, HF hospitalization, worsening NYHA class) 3.9% vs 4.1% $p=NS$.^{3 ADVANCE}
25. Glyburide vs rosiglitazone; \downarrow **HF (serious events) NNT 167/3.5 yr**, \downarrow **HF (total events) NNT=67/3.5 yr**.^{4 ADOPT}
26. Pioglitazone vs placebo; \uparrow **hospitalization for HF NNH=50/2.9 yr** (not adjudicated), \uparrow **edema (without HF) NNH=8/2.9 yr**.^{5 PROACTIVE}
27. Rosiglitazone +metformin or SU vs control; \uparrow **hospitalization for HF or HF death NNH=69/5.5 yr**.^{6 RECORD} Rosiglitazone vs placebo; \uparrow **HF NNT=250/3 yr**.^{7 DREAM}
28. Acarbose vs placebo; impaired glucose tolerance; HF 0% vs 0.3% $p=N/A$.^{8 STOP-NIDDM}
29. Repaglinide vs rosiglitazone: peripheral edema 0% vs 3.2%, $p=N/A$.⁹
30. Saxagliptin vs placebo; \uparrow **hospitalization for HF NNH=143/2.1 yr**; however, subgroup without a history of HF at baseline \uparrow **hospitalization for HF NNH=147/2.1 yr**, subgroup eGFR <60 mL/min \uparrow **hospitalization for HF NNH=68/2.1 yr** & no difference from 12 months on HR 1.05, 95% CI 0.81-

20. Insulin basal/bolus vs conventional diet; all-cause mortality 18.6% vs 19.9% p=NS, MI 15.8% vs 17.9%

HF/Edema- cont'd

- 1.35.^{10,11} **SAVOR-TIMI 53** Alogliptin vs placebo; hospitalization for HF 3.9% vs 3.3% p=0.22; subgroup without a history of HF at baseline ↑ hospitalization for HF **NNH=111/1.5 yr.**^{12,13} **EXAMINE** Sitagliptin vs placebo; hospitalization for HF 3.1% vs 3.1% p=0.98; and neutral results when adjusted for baseline HF (aHR 1.00, 95% CI 0.83-1.20 [unpublished data]).^{14,15} **TECOS** Meta-analysis(**SAVOR-TIMI 53, EXAMINE, TECOS**) HF admission RR 1.12 (95% CI, 1.00-1.25, I²=42%).¹⁶ FDA warnings for both saxagliptin & alogliptin.¹⁷
31. Liraglutide vs placebo; hospitalization for HF: 4.7% vs 5.3% p=0.14.¹⁸ **LEADER** Lixisenatide vs placebo; hospitalization for HF: 4.0% vs 4.2% p=0.75.¹⁹ **ELIXA**
32. Empagliflozin vs placebo; hospitalization for HF: 2.7% vs 4.1% p=0.002.²⁰ **EMPA-REG** Empagliflozin in HF patients (regardless of diabetes status) ongoing trial estimated to be complete 2020 **EMPEROR-Reduced & Preserved**. Canagliflozin vs placebo; hospitalization for HF: 5.5/1000ptys (0.55%/yr) vs 8.7/1000ptys (0.87%/yr) (HR 0.67, 95% CI 0.52-0.87) follow up 3.6yr but **exploratory**.^{27a} **CANVAS**
33. Basal insulin (glargine) vs standard care; hospitalization for HF 4.9% vs 5.5% p=NS.²¹ **ORIGIN**
34. Basal insulin vs basal/bolus insulin; small sample n=152; HF 1.3% vs 5.3% p=NS.²² ArchInternMed1997

Other

35. Pioglitazone & Rosiglitazone **FDA** +/- Health Canada warnings/label changes:
- ?↑ HF (see above) **1 PROACTIVE, 2 RECORD, 3 DREAM, 4, 5**
 - ?↑ fractures ♀; pioglitazone vs placebo 5.1 vs 2.5%, calculated p=0.005 ?↑ fractures ♀ **NNH=38/2.9 yr** (unpublished **PROACTIVE** data).⁶ Rosiglitazone vs MF ↑ fractures ♀ **NNH=24/4 yr**, rosiglitazone vs glyburide ↑ fractures ♀ **NNH=17/4 yr.**⁸ **ADOPT** Post marketing data: pioglitazone exposure in women associated **0.8 excess fractures (distal upper and lower limbs)/100 patient-years** vs comparator treated group.⁸ No ↑ risk in males.^{8,9}
 - ?↑ diabetic macular edema: retrospective cohort, TZD users vs nonusers ↑ macular edema 1 yr follow up aOR 2.3 (1.5-3.6) & 10 yr follow up HR 2.3 (1.7-3.0).¹⁰ Cross-section of **ACCORD** ↑ macular edema aOR, 0.97 (0.67-1.40).¹¹ Note- only rosiglitazone has a warning.¹²
36. Piog: ?↑ bladder cancer; France, retrospective observational cohort pioglitazone exposure vs other diabetic agent HR 1.22 (1.03-1.43), pioglitazone exposure **cumulative dose > 28 000 mg** vs other diabetic agent HR 1.75 (1.22-2.5), pioglitazone **exposure >12 months** vs other diabetic agent HR 1.28 (1.09-1.51).¹³ US, prospective observational cohort (5 yr interim analysis) pioglitazone exposure vs never exposed HR 1.2 (0.9-1.5), pioglitazone exposure >12 months vs never exposed HR 1.4 (0.9-2.1), & pioglitazone exposure >24 months vs never exposed HR 1.4 (1.03-2.0).¹⁴ FDA calculated pioglitazone >12 months associated **27.5 excess cases of bladder cancer /100,000 person-yr**s vs never exposed.^{15,16}
37. Rosiglitazone **FDA** +/- Health Canada warnings/label changes: restricted access- in Canada (SK-EDS) due to ?↑ CV events- see MACE/mortality.¹⁷⁻²¹
38. DPP-4 inhibitors FDA +/- Health Canada warnings/label changes:
- ?↑ HF risk with saxagliptin and alogliptin (see above).^{10,11} **SAVOR-TIMI 53, 12,13 EXAMINE,16, 22**
 - ?↑ arthralgia risk; n=33 cases of severe arthralgia, of which n=10 cases were hospitalized due to disabling joint pain; n=8 cases reported a positive rechallenge (2006-2013).²³
39. Incretin agents (DDP-4 inhibitors and GLP-1 agonists) ?↑ pancreatitis:²⁴ Meta-analysis of **SAVOR-TIMI 53, EXAMINE, & TECOS** (n=36,395) demonstrated ↑ acute pancreatitis **OR 1.79 (1.13-2.82) and ARI of 0.13%** vs placebo.^{24a} US case control study; incretin agent (exenatide or sitagliptin) within 30 days **aOR 2.24 (95% CI, 1.36-3.68).**²⁵ FDA: n=30 cases of pancreatitis with exenatide of which n=21 cases hospitalized, n=3 cases reported positive rechallenge.²⁶ FDA: n=88 cases of pancreatitis with sitagliptin or sitagliptin/metformin of which n=58 cases were hospitalized (n=4 cases admitted to the ICU), n=2 cases of hemorrhagic or necrotizing pancreatitis.²⁷ Listed adverse event for other agents (e.g., liraglutide) in product monograph.
40. Incretin agents (DDP-4 inhibitors and GLP-1 agonists) ?↑ pancreatic cancer: n=13 pancreatic cancer cases suspected of being associated with all incretin-based therapies (July 31, 2014).^{24,28}
41. Liraglutide: ?↑ thyroid C-cell tumor (including medullary thyroid carcinoma) in **animal** studies (both genders, dose-dependent, and treatment-duration-dependent).²⁹

Other- continued

- weekly 59% vs exenatide BID 35% (clinical development of tasoglutide has been stopped).³² ↓ **GI AE**: Exenatide once weekly 28% vs exenatide BID 48%, albiglutide once weekly 29.8% vs liraglutide daily 52%, exenatide once weekly 19.1% vs liraglutide daily 44.5%.³³ **DURATION-5,34 HARMONY-7,35 DURATION-6**
- Neutral GI: dulaglutide once weekly 39.4% vs liraglutide daily 38.3%.³⁶ **AWARD-6**
43. SGLT-2 inhibitors **FDA** +/- Health Canada warnings/label changes:
- ?↑ diabetic ketoacidosis; n=5 Canadian cases, some requiring hospitalization (May 2016); n= 73 US cases (n=44 T2DM cases, n=15T1DM cases, n=13 NR) (Mar 2013-2015) all requiring hospitalization or emergency department care.^{37,38}
 - ?↑ urosepsis & pyelonephritis; n=19 cases requiring hospitalizations (canagliflozin [n=10 cases] and dapagliflozin [n=9 cases]), of which n=4 cases required ICU admission and n=2 cases required hemodialysis (Mar 2013-Oct 2014).³⁸
 - ?↑ AKI; n=2 Canadian cases (Canagliflozin) (Oct 2015); n=101 US cases (Mar 2013-Oct 2015), of which n=96 cases required hospitalization (n=22 cases required ICU admission), n=15 cases required hemodialysis, and n=4 cases resulted in death. ~50% of cases occurred within 1 month of drug initiation; empagliflozin not included in review due to recent approval.^{39,40}
 - ?↑ fracture; canagliflozin 100 mg-300 mg vs placebo follow up 3.6yr; 15.4/1000ptys (1.54%/yr) vs 11.9/1000ptys (1.19%/yr) NNT= 285/yr (HR 1.26, 95% CI 1.04-1.52)., **CANVAS** ?↓BMD (total hips, lumbar spine, femoral neck, & distal forearm).⁴¹
 - ?↑ lower limb amputation; canagliflozin 100-300 mg vs placebo follow up 3.6yr; ↑ all amputation 6.3/1000ptys (.63%/yr) vs 3.4/1000ptys (0.34%/yr) NNH=345/yr (HR 1.97, 95% CI 1.41-2.75) & ↑ major amputation (ankle, below/above knee) 1.8/1000ptys (0.18%/yr) vs 0.9/1000ptys (0.09%/yr) NNH>1000/yr (HR 2, 95% CI 1.08-3.82) . **CANVAS** Other trials neutral.^{e.g., CANVAS-R}^{42,43} May2017 **FDA**: canagliflozin -increased risk of leg and foot amputations. https://www.fda.gov/Drugs/DrugSafety/ucm557507.htm?source=govdelivery&utm_medium=email&utm_source=govdelivery
44. ?↑UTI; SGLT2 inhibitor vs placebo: **OR 1.34 (1.03-1.74, I²=0%)**, vs active agent: OR 1.42 (1.06-1.9, I²=25%). ↑ genital tract infection; SGLT2 inhibitor vs placebo **OR 3.50 (2.46-4.99, I²=0%)**, vs active agent: OR 5.06 (3.44-7.45, I²=0%).⁴⁴
45. Dapagliflozin: ? ↑ bladder/breast cancer; approved by FDA 2014 (rejected in 2012 due to breast & bladder cancer concerns). Dapagliflozin vs control; bladder cancer: n=10 cases vs n=1 case & breast cancer: n=12 cases vs n= 3 cases (up to 2013).



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42.↕/↗ GI (nausea, diarrhea, vomiting) AE with long acting agents^{30,31}: ↗ GI AE: taspoglutide once

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